

PROCEEDINGS OF THE THIRTY-THIRD INDIAN SCIENCE CONGRESS BANGALORE, 1946

PART II : PRESIDENTIAL ADDRESSES

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THIRTY-THIRD INDIAN SCIENCE CONGRESS

BANGALORE, 1946

Congress President: PROF. M. AFZAL HUSAIN, M.A., M.Sc., F.N.I.

PRESIDENTIAL ADDRESS

(Delivered on 2 January, 1946)

I am most grateful to the scientists in India for the honour they have done me in inviting me to preside over the thirty-third Session of the Indian Science Congress.

This is the fourth time that we have assembled in Bangalore. The warmth of our hosts' reception and their lavish hospitality are overpowering attractions; but perhaps even stronger than these is the magnetic force of the scientific spirit that pervades this city. May I remind you of His Highness the Maharaja of Mysore's message to the 11th Session of the Indian Science Congress, which met here in January, 1924 :

" it will be evident," His Highness said, "to even the most sceptical mind that wider interest in scientific enquiry is the surest foundation of national prosperity and well being that can be laid"

The spirit of this message has guided the policy of this State. Mysore was the first to develop hydro-electric power in India, and thus made possible the development of several industries—iron and steel, cement, chemicals and fertilisers, textiles, paper, leather, porcelain, oil, soap, matches, tobacco, and electric goods, to mention but a few. Again it was in Bangalore, that through the co-operative efforts of a philanthropic benefactor, Mr. J. N. Tata, the Mysore Durbar and the Government of India, a national organization—the Indian Institute of Science—was established. This institute has rendered valuable services to India during peace and war, and has won approbation as a centre of training and research in pure and applied sciences.

The year that has just closed has witnessed substantial progress in the scientific development of this country. The Government of India has given official recognition to the National Institute of Sciences of India. This is an appreciation of the ever-increasing importance of science in the life of this country. The question of a Royal Charter to the Institute is receiving consideration.. As devotees of science it is our sacred duty to do all we can

to further the cause for which this Institute stands, *viz.*, the development of science in India. It is only through the whole-hearted co-operation and good-will of every scientific worker in this country, that our National Institute can attain the eminence in the World of Science that it deserves.

During the next few years international co-operation among scientists is sure to develop greatly, because, it will be realized, the co-operation of scientists and not the wranglings of politicians can rehabilitate this stricken world. It will also be realized that scientists alone can stop future wars by producing such abundance of the necessities of life, that the needs of the whole of mankind will be abundantly met, and thus the *casus belli* will disappear. Or, if necessary, by the discovery of more frightful weapons of destruction, such conditions would be produced that no nations would dare to settle disputes by an appeal to the arbitrament of the atomic bomb. Atomic energy can be utilised for both purposes. The National Institute, as an organization of scientists in India, is sure to play an important role in furthering such co-operation.

I know I am voicing your feelings when I say that we in India welcome to the fullest extent this international co-operation, because we know we have a contribution to make to the development of the world and to the common heritage of all mankind. As time goes on, we shall be able to develop our scientific institutes more and more and take a full share in the advancement of human knowledge and its application to the affairs of man. The Tata's have given us a National Institute of Fundamental Research. The Department of Scientific and Industrial Research has gone from strength to strength. We welcome the Indian Institute of Glass Technology, and expect an early establishment of a National Physical Laboratory, and a National Chemical Laboratory.

We hope to see the extension of existing research facilities and the establishment of further teaching and research institutes for pure and applied sciences, and in the fields of agriculture and industry. There are several schemes for all-round post-war development in India and in their planning and materialization scientists have to play an important part. We look with satisfaction at the schemes of training and scholarships initiated by the Central and Provincial Governments, and several States.

All this progress is most encouraging, but it must be realized, that glorious edifices, excellent equipment, abundant staff do not make a research institute, if the true spirit of research is not there. Research atmosphere develops from selfless devotion to the cause of science. Teachers and pupils, old and young, must work together for the glory of science. Now that we have a chance to develop science in our country, let us establish honourable traditions worthy of a great cause—the advancement of human knowledge.

THE FOOD PROBLEM OF INDIA

INTRODUCTION

Famine and pestilence have always followed wars ; and this is happening to-day. Of the problems of peace, perhaps, there is not one so important and so pressing as that of the food supply of the people of the world. In the United Kingdom control over food continues, and rations of certain food stuffs are lower than they were during the war. In the United States

of America—that land of plenty—butter and sugar were severely rationed during the later part of last year. The people of Europe are facing starvation. In the Far East there is a serious food shortage. The Indian food situation has not improved, and food controls are likely to continue for a period which it is not possible to determine at present. “The food situation in India,” said Mr. Arthur Henderson in the House of Commons, on December the 19th, “gives no grounds for complacency and substantial assistance in the form of cereal imports from abroad is still necessary.”

A study of the problem of nutrition has revealed that, even during peace and prosperity, nutritional standards have been grossly unsatisfactory for a large proportion of the population.

For the first time in the history of the world, a Conference of United Nations was called, in 1943, at Hot Springs, signifying that the true status of the food problem was at last recognized. The declaration of this Conference runs :

“There never has been enough food for the health of all people. This is justified neither by ignorance nor by harshness of nature. Production of food must be greatly expanded ; we now have the knowledge of the means by which this can be done. It requires imagination and firm will on the part of each government and people to make use of that knowledge.”

This Conference made the following recommendation :

“That the governments and authorities here represented :— Immediately undertake the task of increasing the food resources and improving the diets of their people in accordance with the principles and objectives outlined in the findings of the Conference, and declare to their respective people and to other governments and authorities here represented their intention of doing so.”

As a result of the Hot Springs Conference a Food and Agriculture Organization has been set up. A conference of this international body met at Quebec in October, 1945, and was attended by a strong contingent of representatives of India. In his address, Sir John Boyd Orr, the first Director General of FAO, stated that the signatory nations had not only accepted the responsibility to provide as far as possible food and health standards for all the people they governed, but they had also agreed to co-operate in a great world scheme which would bring freedom from want of food to all men, irrespective of race and colour.

The practical programme for immediate action as recommended by the Committee on Nutrition and Food Management includes the following items :

“FAO must employ all the means at its disposal to relieve existing hunger and mal-nutrition. A rapid survey should be made of available food resources and the supplies and requirements of necessitous countries assessed. Every effort must be then made to have supplies of food directed where they are most needed, to stimulate the production of food in short supply, and to ensure that the utmost value, in terms of nutrition, is obtained from available food by all known means. . . .”

Such being the position, no apology is needed for placing before the scientists of India the very mundane problem of ‘our daily bread.’ It will

be recognized that the Food Problem of India is of fundamental importance and of very great urgency, not only for this country but for the entire world, because the population of India represents one-fifth of the human race.

STATISTICS

What is the problem ?

One is at the very outset faced with several serious difficulties when enunciating the Food Problem of India. For a scientific appreciation of any phenomenon and for the formulation of a policy, certain fundamental data are essential ; moreover such data must provide a realistic statistical expression of the material under study . For instance, to appreciate the food position of a country and to formulate a food policy for a nation, it is necessary that the data regarding the total requirements, available quantities of different categories of food and potentialities of increased production be ready to hand. In the case of India, lack of this precise information is the first difficulty. The importance of agricultural statistics was emphasized by the Indian Famine Commission of 1880, and since then the necessity of accurate statistics has been stressed by every committee and commission that has dealt with agricultural production. The Royal Commission on Agriculture in India recommended that the whole basis of statistics in India urgently required broadening, and laid emphasis on the fact that modern statistical methods were to make 'indispensable contribution to the successful development alike of agriculture and of social administration.' And yet, 18 years afterwards, the Famine Inquiry Commission of 1945 recorded :

"Problems arising out of the production and distribution of food-grains during the war, have emphasized the need for accurate statistics of acreage and yield of crops ; schemes, largely experimental in character, are now in operation with the object of securing improvements in these statistics."

Without an accurate and precise assessment of food requirements and agricultural production, no agricultural planning is possible. In countries where literacy is widespread the farmers themselves help to supply the required information ; but in this country statistics of every type must be collected by a suitable agency, having adequate and well trained staff.

It has to be recognized that to be useful an agricultural survey must be comprehensive, accurate, and quick, and it must at the same time be cheap. These opposing tendencies make the task difficult. There is evidently need for a carefully developed technique. Aerial survey for crop acreage should prove in the long run comprehensive, accurate, quick and cheap. The present is a suitable time for undertaking such an experiment, as trained personnel and up-to-date equipment are available, and the technique of aerial photography has greatly developed. To obtain figures of yield special equipment will have to be designed. It should be possible, for instance, to devise a harvester which would reap a narrow strip of wheat, thresh and clean it and give the weight of grain.

If it is proposed to plan on a sound basis then the development of the science of statistics must be an important item in the post-war programme. Ignoring this branch of science will mean building the post-war edifice of progress on a foundation of sand.

Starting with this fundamental handicap let us face the issue before us, and formulate our food problems, on the basis of available data.

POPULATION

What are our present requirements of food ? And what will they be in the immediate future ?

The census returns for 1941 gave the population of India as 389 millions, an increase of 51 millions over the 1931 figures, or, an increase of 1.5 per cent. per year. It will not be incorrect to say that, at this rate of increase, India starts the year of grace 1946 with a population approximating to 415 millions. Even if there is no acceleration in this speed the population of India will exceed 500 millions before 1960.

From 1901 to 1940 the recorded birth rate has shown a slight decline, but during the same period the death rate has shown a marked fall.* Ignoring the years of war as exceptional, the excess of births over deaths has been increasing steadily and for the decade 1931-1940 the excess of births over deaths was 11 per mille. If this tendency, whatever its causes might be, continues, the rate of increase of the population will be progressively faster. Hill estimates that the population will be 650 millions by 1970. This is by no means an over-estimate. In other words in twenty-five years we shall have 235 million extra mouths to feed. Past experience justifies such an assumption. The country must be prepared to face this situation unless some calamity befalls us, reduces our population, and solves the problem for us.

FOOD RESOURCES

The questions that arise are : What are our food resources to-day ? And further : What are the possibilities of our food resources keeping pace with the increase in population ?

One answer to these questions is :

"All the available evidence goes to show that the average duration of life in India is about half what it might be and that this abbreviated existence is lived at a very low level of health and comfort. There is some difference of opinion as to whether the conditions of life have improved or deteriorated during the past fifty years, but even if some slight improvement may have taken place, the existing state of affairs is still so profoundly unsatisfactory that it demands investigation and redress.

"Even more disquieting is the forecast for the future ; there is every reason to believe that the maximum increase which can be hoped for in the production of the necessities of life will not keep pace with the growth of the population, so that there is a prospect of a steady

*Birth and death rates :

Period	Per mille		Remarks
	Birth rate	Death rate	
1901—1910	38	34	Decline in death rate due to decline in infantile mortality and decrease in mortality from epidemics of cholera and plague.
1911—1920	37	34	
1921—1930	35	26	
1931—1940	34	23	
1941	32	22	Increase in death rate probably due to famine.
1942	29	21	
1943	26	23	

deterioration in the state of the nutrition of the people." (Major-General Sir John Megaw).

A distressing picture !

The position taken up by the Royal Commission on Agriculture in India is :

"That production has increased is beyond dispute ; some part of this increase is due to the enhancement of yield resulting from the expansion of irrigation, but a far larger part is due to the spread of cultivation. Only a small proportion of it can be attributed to the introduction of the higher yielding varieties of crops and it is doubtful if any appreciable increase in yield can be attributed to the adoption of better methods of cultivation or the increased use of manure."

Thus the expansion of cultivation and the extension of irrigation are the two factors of increased food production.

What has been the contribution of these factors ?

Since 1911, 7 million acres have been added to the area under cultivation in British India, but in spite of this addition the area sown per capita has declined from 0.9 acre to 0.72 acre, *i.e.*, by 25 per cent. During the 30 years ending 1941, the area of land under irrigation increased by 14 million acres. If it be accepted that an irrigated area gives double the yield of an unirrigated area, then, in terms of unirrigated area, the total extension of cultivation may be computed at 21 million acres. On this basis the area sown per capita has decreased from 1.079 acres in 1911 to 0.916 acre in 1941, *i.e.*, by 18 per cent. Therefore, 18 per cent. increased production is necessary to maintain consumption per capita at the level of 1911. This increase could only be attained by the increased use of manures and fertilizers, extensive use of better varieties and increased application of methods to reduce wastage. It can hardly be denied that the use of manures and fertilizers has not increased and no large scale measures to reduce wastage have been effected. The proportion of better-yielding varieties is indeed very low. It is a little over 22 per cent. in the case of wheat, 6.2 per cent. in the case of rice and 1.1 per cent. in the case of jowar. At a most liberal estimate all the improvements effected in the yield of cereal crops still leave a deficit of 15 per cent. in the quantities necessary to provide the same rations per capita as were available in 1911.

Area sown per capita : British India

Year	Population (Million)	AVERAGE NET AREA SOWN			Area sown per capita (acres)	AREA IN TERMS OF UNIRRIGATED AREA		Percentage increase in yield per acre to maintain 1911 standard.
		Irrigated (Million acres)	Unirrigated (Million acres)	Total (Million acres)		Total (Million acres)	Per capita (acres)	
1911	231.6	42	166	208	0.90	250	1.079	—
1921	233.6	46	159	205	0.88	251	1.074	0.5
1931	256.8	49	162	211	0.82	260	1.012	7.0
1941	295.8	56	159	215	0.72	271	0.916	18.0

Reduction in the export of food grains and increase in imports of rice may together amount to a 5 per cent. increase in the available supply. Even then India is short of food grains by at least 10 per cent. per capita when

compared with conditions which existed thirty-five years ago, and at that period food was by no means plenty, and famines were not unknown. There is thus not the slightest doubt that the food position has been deteriorating.

Let us compare our position with that of the United States of America, which shows a higher yield per acre of all crops when compared with India. Baker calculated that for a "liberal" diet containing meat, fruits and green vegetables in maximum quantities and a quart of milk per day, 3.1 acres of land were required per capita. For an "adequate" diet this area would vary from 1.8 acres to 2.3 acres per capita, according to the quantity of milk and other nutritious foods included in the diet. An "emergency restricted diet," which contained mainly cereals and was designed to tide over difficult times and short periods of privation, 1.2 acres per capita was the minimum required. Even this is 33 per cent. more than the area per capita available in India. This comparison is enough to show the low nutritional standard of the population in this country.

DEFICIENCIES AND THEIR CONSEQUENCES

It has been estimated that to feed a population of 400 million India needs an increase in cereals to the extent of 10 per cent., in pulses to the extent of 20 per cent., in fats and oils 250 per cent. in fruit 50 per cent., in vegetables 100 per cent., in milk 300 per cent., and in fish, flesh and eggs 300 per cent. These figures are staggering, because first of all these deficiencies have to be made up for the proper nutrition of the existing population, and a further increase has to be assured to meet the demands of the increasing population. For instance, to provide adequate nourishment for a population of 500 million in 1960, the production of cereals will have to be increased by 37.5 per cent., pulses by 50 per cent., fats and oils by 337.5 per cent., milk and fish, flesh and eggs by 400 per cent. With such deficiencies in food resources, it is not surprising that the Nutrition Advisory Committee have found from the results of actual "surveys of both typical urban and rural groups that the calorie intake of some 30 per cent. of families is below requirements and that even when the diet is adequate it is almost invariably unbalanced, containing a preponderance of cereals and insufficient protective foods of high nutritive value." There cannot be any disagreement on the point that "mal-nutrition promotes a state of ill-health and lower physical efficiency, short of actual disease, which are perhaps more important because more widespread than disease itself." Therefore, the Nutrition Advisory Committee correctly lays stress on the fact that "freedom from disease is one thing, abundant health is another" and "the goal to be aimed at is the creation of a healthy and vigorous population."

SOLUTION OF THE PROBLEMS

How to attain this goal ?

The solution of the complex problem of providing adequate food for our population lies in the increase of the supply and, if possible, the decrease of demand.

Check on the growth of population

At one extreme we have those who maintain that India is greatly over-populated and that her food resources have not kept pace with the rise of population and are progressively falling short of the minimum requirements and, therefore, "our present need is that the growth of population should be checked and even its decline welcomed !" They say : "Judged

from any point of view a check on the growth of the population of India is an urgent necessity." (Chand). There can be no doubt about the urgency of such an attempt as it would bring about a measure of relief and allow scope for adjustment. A stationary population for some years would avoid "futility and frustration" which the present situation strongly suggests. However desirable, a check on the growth of population may be, it is difficult to attain. Nevertheless, we may look at this problem from another point of view. The United Nations have now accepted the responsibility for meeting the food requirements of all people. They must, therefore, determine the production of food and control its distribution. We are already hearing of world's wheat pools. The necessary corollary to this responsibility is that the United Nations will have to watch the population trend of various countries. What will be the attitude of the nations with a low or controlled birth rate towards another nation with an uncontrolled and very high birth rate? Will not the United Nations Organization be justified in exercising some control over population? Having accepted membership of the community of nations, India will have to fall into line with the rest of the world. The solution of the population problem is not easy and at any rate it will be many years before a satisfactory solution can be found. In the meantime an increase in population will continue.

Increase in food production

On the other hand there are those who firmly believe that "Nations can live at home" (Wilcox), and see in the development of the modern science of agrobiolgy the possibility of a manifold increase in the produce from land. They claim that the problem is not of *over population* but of *under-development* of the natural resources and inadequate utilization of human knowledge to develop these resources. For instance, Wilcox places the theoretical limit of the yield of wheat at 171 bushels and of potatoes at 1,330 bushels, while the average in the U.S.A. is only 8.4 percent. of this 'penultimate' limit in the case of wheat and 8.6 in the case of potatoes.

Importance of the time factor

We have seen that there is immediate need to improve our food position. Neither the policy of population reduction nor the magic wand of agrobiolgy can bring forth immediate results. The time factor is important. The Bengal Famine and insecurity of the food position are clear warnings. A sound policy would be to base our programme on the results previously achieved and attempt to evolve a scheme of increased food production from existing resources, leaving future enhancement of production for the increased population.

Cereal mentality

Unfortunately, determining food requirements by calories has produced an attitude more in favour of quantity than quality, and this has made it difficult to arrive at a scientifically correct food policy. Cereals have assumed unnecessary importance at the expense of "protective" foods. All those who have studied the food problem of India have emphasized this point. Colonel Macay held that with a low protein consumption deficiency in stamina, moral and physical, must be expected. According to John Russell the well-balanced diet for India "does not require more but less cereal than at present, but it includes more of everything else, especially vegetables, fruit and milk, and one great need for the food supply is to increase the production of these three." He advocated an increase in the yield of staple crops so

as to liberate land for the cultivation of supplementary foods. India's ill-balanced diet, which has led to extensive mal-nutrition, is a far more serious national problem than mere deficiency in the quantity of food. The population is degenerating in physique and in stamina. How else can one explain the curious phenomenon that lakhs died in Bengal without attempting to obtain food by fighting for it ! To arrive at a correct appreciation of the food situation, it is necessary to deal with the various constituents of the diets, and not talk of calories, however, convenient the slogan may be.

Let us shake off the cereal mentality and the talk of carbohydrates, fats, proteins, minerals, vitamins and so on, and make an attempt to evolve a scheme of a 'balanced diet' containing as far as possible all the ingredients in their correct proportions.

I shall first deal with the carbohydrates, which form the greatest bulk of food.

REQUIREMENTS OF CARBOHYDRATES

The present position is that over 72 per cent. of the carbohydrates of human food are derived from cereals, about 20 per cent. from sugarcane, and the balance mainly from pulses. India with 90 per cent. of her cultivated area under food crops and 64 per cent. under cereals, is short of rice and is barely self-sufficient in other cereals. In spite of an intensive "Grow More Food" campaign, increased production has not kept pace with increased demand, and India is seeking imports at least at the pre-war level. It does not seem likely that India will obtain rapidly enough such a phenomenal rise in her soil fertility, such colonization of vast tracts of land, such rapid extension of irrigation*, as to make up the existing deficiencies and provide for the future population, from a cropping scheme built round 64 per cent. area under cereals.

In the circumstances India must produce, per acre, quantities of carbohydrates much in excess of what cereals can possibly yield. Because, if the required quantities of fuel foods can be produced from a smaller area, it would be possible to release land for the increased production of pulses, fats and oils, and "protective" foods of vegetable and animal origin, in which India is greatly in deficit. Tubers will satisfy this requirement.

Tubers

No statistics are available which will give information about the production of tubers in India, except that potato is grown over 0.5 million acres, and sweet-potato and cassava are grown on what is described as an 'enormous area.' In densely populated tracts the farmers have developed a farm economy with practical results in view, and in this tubers have an important place for instance, sweet-potato in Bihar and cassava in Travancore. During the war the area under these two tubers has increased, not on account of any special propaganda, nor through financial aid or efforts of administration, but almost entirely because of the well-established efficiency of these crops to provide cheap and abundant food, and the ease with which they can be grown under diverse climatic conditions and soils of varying potentialities. The Indian cultivator is more realistic than he is often credited to be.

* Irrigation is faced with the serious problem of waterlogging and development of salts. It is estimated that in the Punjab an area approximating to 2 million acres has gone out of cultivation, and to this 30 to 40 thousand acres are being added every year.

In all countries where the population has increased, cereals have been increasingly replaced by tubers.* For instance in Germany, area under potatoes is 25 per cent. of that under all cereals. In England, it is 17.8 per cent. Even U.S.S.R. has 17.6 million acres under potatoes. In Java, one of the most thickly-populated parts of the globe, there has been, since 1916, a great increase in the cultivation of cassava and sweet-potato (see page 13). In many countries of Europe potato shares with cereals, more or less, on a basis of equality, in the carbohydrate supply of the human diet. Even in the United States, in spite of the availability of land, the ratio of cereals and potatoes in the diet of a household of the lowest income is 79.8 to 64.4.†

Food value of tubers

As regards their food value : reduced to the same standard of moisture, tubers are richer in carbohydrates, mineral matter and calcium than cereals ; they are, however, poorer in proteins and deficient in fats.** The great advantage of tubers over cereals is the yield per acre. If the average yield of rice and wheat in India be taken as 10 maunds per acre (although it is less),

*Area under potatoes, wheat and all cereals. Average of 5 years ending 1938 or 1939.
(Modified from the *Famine Inquiry Commission Report, 1945*)

Area in thousands of acres				
	Potatoes	Wheat	All Cereals for grain	Percentage of 1 & 3
	(1)	(2)	(3)	(4)
India	440	34,485	179,276	0.3
Germany	7,054	5,175	28,176	25.0
France	3,511	12,904	25,864	14.0
United Kingdom ..	733	1,863	4,124	17.8
U.S.A.	3,276	55,557	215,066	1.5
U.S.S.R.	17,601	85,802	244,222	7.2

†Quantities (Kgs.) of cereals and potatoes consumed per year per unit of consumption, for a household of lowest income. (Workers' Nutrition and Social Policy published by International Labour Office, 1936).

	Cereals	Potatoes
Germany	138.5	147.8
Belgium	225.54	230.19
Poland	198.63	175.14
Czechoslovakia ..	197.89	118.01
Sweden	112.9	101.1
Finland	129.9	110.35
United Kingdom ..	97.3	78.1
United States ..	79.8	64.4

Note—Difference between the consumption of potatoes and cereals from country to country is because of other items of food.

**Comparative food values with approximately the same amount of moisture

	Rice, raw home- pounded	Whole wheat	Potato	Sweet Potato	Tapioca
Moisture %	12.2	12.8	Dehydrated to 12.2 moisture %		
Protein %	8.5	11.8	5.6	3.1	1.5
Fat (Ether Extractives) %	0.6	1.5	0.35	0.78	0.43
Mineral Matter % ..	0.7	1.5	2.1	2.6	2.16
Carbohydrates % ..	78.0	71.2	79.5	81.2	83.7
Calcium %	0.01	0.05	0.03	0.05	0.01
Phosphorus %	0.17	0.32	0.01	0.13	0.08

and the average yield of potatoes be taken as 75 maunds per acre (although it is more than 100 maunds), the per acre yield of various constituents of food will be very much higher in the case of tubers, except fat in potato and protein in cassava.*

With a reasonable standard of cultivation, a yield of 200 maunds per acre is not difficult to attain in the case of potato, sweet-potato and cassava. With this yield the potato will provide a quantity of carbohydrates at least four times that of wheat, and sweet-potato and cassava about five times.

The superiority of rice and wheat in contrast to tubers is their high protein content. There seems no reason why India should persist in obtaining her protein supply from cereals. She must obtain the various ingredients of diet from sources from which they can be produced most efficiently and economically. In other words, carbohydrates must be obtained mainly from tubers and cereals, if possible in equal proportions; proteins from pulses and animal sources, such as milk, fish, flesh and eggs; fats and oils from milk and oil seeds; minerals, vitamins and other ingredients from such sources as supply them most economically.

In addition to providing large supplies of carbohydrates, minerals, calcium and phosphorus per acre, tubers can be used as fodder for live-stock, as a source of starch for food products, such as biscuits, and as a raw product for the manufacture of dextrine, glucose and sizing for the textile industry. In these respects they outstrip cereals. From the agricultural point of view, they loosen the lower strata of soil and lead to soil improvement. Potatoes respond to better cultivation and provide increased occupation for the farmer. There are some varieties of tubers that yield two and three crops a year, in which case the yield per acre is exceedingly high.

Potato

As an illustration of the tremendous potentialities of tubers and the part which they are destined to play in the food resources of mankind, the present world position of potatoes—the favoured tuber of Europe and America—may be cited. What applies to potato will apply with equal force to sweet-potato and cassava. Potato is one of the cheapest and commonest sources of carbohydrate food. The average annual pre-war world production of potato was about 6 million bushels, which very nearly approximated to wheat in value. The comparative annual production of the three chief food crops of the world is as follows:

	World production (million maunds)	Quantity of carbohydrates (million maunds)
Potato ..	6010	1376
Wheat ..	3534	2517
Rice ..	2411	1880

*Quantities of different ingredients per acre

	Rice at 10 maunds	Wheat at 10 maunds	Potato at 100 maunds	Sweet- Potato at 100 maunds	Cassava at 100 maunds
Proteins (lb.) ..	68	94	128	96	56
Fats (lb.) ..	4.8	12	8	24	16
Carbohydrates (lb.) ..	624	570	1832	2480	2296
Mineral matter (lb.) ..	5.6	12	48	80	80
Calcium (lb.) ..	0.08	0.4	0.8	0.16	4.0
Phosphorus (lb.) ..	1.36	2.56	2.4	4.0	3.2
Calories (in thousands)	1,280	1,258	2,584	4,776	5,760

Nixon said in 1931 : "The part that the potato plays at the present time in maintaining life, through supplying food to the most densely populated continent, serves to direct our attention to the part it is destined to play as the source of food in our own country (U.S.A.) and in our own continent (America) in years to come. The famines which normally devastated Europe became much less frequent after the potato was cultivated as a field crop" He added : "We need only ask what the universal adoption and the scientific production of potato would mean to the starving millions of China." What applies to China applies with equal force to India.

In Germany, before the present war, the area under potatoes was 7 million acres. This exceeded that under wheat by 2 million acres and was about 25 per cent. of the total area under cereals. According to Wallace (1938) "Without the potato the great war could not have been fought : certainly it furnished a great reservoir of power and food for the German people and occupied a very prominent place in the dietary of our own folk." Nixon describes the potato as "truly the greatest public servant in the world."

The greatest obstacle in the extension of the area under potatoes in India is the non-availability of sound, healthy seed in adequate quantities, at the right time and at a reasonable price. The crop grown in the plains gets diseased and, therefore, seed has to be brought from the hills or imported from abroad. Researches have shown that healthy seed can be produced in India, and according to Burns, "given disease-free seed-potatoes and suitable manuring, the production of potatoes on the existing acreage can be doubled." Steps have been taken by the Imperial Council of Agricultural Research for the production and distribution of healthy seed. There are vast areas which provide suitable soil and climatic conditions for potato cultivation and in many parts of India two crops can be raised in a year.

Sweet-Potato

If potato is the tuber of the cooler regions, sweet-potato may with greater justification claim to be the tuber of the warmer regions of the globe. If potato is the tuber of the West, sweet-potato is the tuber of the East. "The Chinese cultivate sweet-potato on a very large scale and it enters into their diet, in some parts even more than rice." During 1943 the U.S.A. had 900,000 acres under sweet-potatoes, mainly in the Southern States. Some varieties of sweet-potatoes are only three-month crops. Even two crops a year, each yielding 200 maunds of tubers, grown over a moderate area, would convert Bihar and Bengal from deficit to surplus provinces, not only for carbohydrates but by releasing area for fodder, which will also increase the supply of milk.

Sweet-potato has this advantage over potato that it can be grown from stem cuttings and the seed problem, the greatest obstacle in the extension of area under potato, does not arise. Again its demands for soil, manure and irrigation are not exacting either.

Cassava

Now I come to the third tuber—cassava. Here I am on difficult ground, because our nutrition experts have given their verdict and condemned it. The accusation is, that people who begin to eat cassava, eat too much of it and suffer from protein deficiency. Like every thing else too much cassava is bad ; but there is not the slightest doubt that it has saved millions of people from starvation and death during famines.

There is the testimony of Yegna Narayana Aiyer as to the value of this plant which should dispel all doubts. He says : "The crop is comparable with the sweet-potato. . . . but the produce is more abundant, the cultivation less laborious and the soil and other requirements less exacting. As a poor man's food there are few crops to equal it. Its introduction to South India, specially in Travancore, was made with the object of relieving distress and as a substitute for rice ; its immediate popularity, which it continued to maintain, shows how well it is adapted for this purpose. Its cultivation deserves to be extended largely in the country."

Tradition has it, that the introduction of cassava into Travancore was due to the efforts of one of the rulers, who wisely foresaw its great potential usefulness as a food crop. True to this tradition, early during the present war, the Travancore Durbar stopped all export of cassava and its products, encouraged increased cultivation of this tuber and thus saved the population from starvation.

It is a high-yielding tuber. A yield of 15 tons per acre has been obtained in certain trials in the West Indies. As a high yielder of starch it has no rival. It has been shown that 30 per cent. of cassava flour mixed with white wheat flour will give bread of as good eating quality as, if not better than, pure wheat bread.

Copeland (1924) gives an interesting table* indicating the importance of cassava in the solution of the food problem of Java, a thickly-populated island, where the area under cassava rose from 639 to 1140 *bouws*, i.e., by over 75 per cent., in five years. And Copeland remarks : " cassava yields more starch to the acre than any other known plant, and is the most likely recourse to supplement rice wherever future increase of population makes an adequate rice supply impossible. At present Java has been forced further in this direction than has any other land. Among the 'other food crops' another root crop, the sweet-potato, is the most extensively planted."

Proposals

The problem is : Must India continue in the tradition's rut, and obtain her requirements of calories and nitrogen from excessive quantities of cereals, or must she break away from tradition and follow the sounder food policy of obtaining a well-balanced diet from sources which provide it best. If India could grow cereals and tubers in the same proportion as the pre-war Germany, i.e., in the proportion of 4 : 1, India could supply in full her present requirements of carbohydrates from an acreage equal to 60 per cent. of what is under cereals now. Even if 10 per cent. of the acreage now under cereals be diverted to tubers, India's carbohydrate supply will be increased by 33 per cent. By following such a policy, land could be released for pulses, oil-seeds, fodders, and a more balanced diet obtained.

*Area under food crops in Java : Thousands of *bouws*—(The *bouw* is 1.73 acres).

			1916	1917	1918	1919	1920
Lowland Rice	..	..	3724	3893	4058	4198	3952
Upland Rice	..	..	550	560	555	640	644
Maize	..	..	2230	2138	2167	2728	2762
Cassava	..	..	639	718	1052	1023	1140
Others	..	..	1036	1118	1362	1235	1207

All tubers are bulky and present difficulties of transport and storage. It should not, however, be difficult to employ modern methods of dehydration and cold storage to overcome these difficulties.

So far practically no research work has been done on tubers in India, with the exception of potatoes, on which work on a small scale has been started recently. Elsewhere it is different. "The Louisiana Agricultural Experiment Station has recently developed methods of handling plants that result in profuse flowering and seed production, thus making possible large-scale plant-breeding work with sweet-potato in this country. In 1939 the Department initiated extensive co-operative breeding and adaptation investigations on sweet-potatoes with half a dozen southern experimental stations."

The proposal, I place before you, is, that if the area under cereals is reduced from the present 64 per cent. of the total sown to 45 per cent. or so, and of the area thus released 5 per cent. of the total sown be planted with tubers, and the acreage of pulses be increased by 20 per cent., the outturn of carbohydrate will be much in excess of the present quantity. I have taken tubers as an instance of high-yielding crops. Equally satisfactory results can be obtained from plantains, which yield over 200 maunds of fruit per acre, and produce as much carbohydrate as sweet potato or cassava with 100 maunds to the acre. They are also decidedly richer in proteins. Another high-yielding crop is carrot, which has the added advantage of being a rich source of carotene.

REQUIREMENTS OF FATS AND OILS

India's requirements of fats and oils have been placed at 250 per cent. in excess of the available supply. The area released from cereals could permit the acreage under edible oil-seeds being doubled. This would also double the quantity of concentrates for feeding milch-cattle, and if a reduction in the number of bullocks can be brought about simultaneously, as suggested later on, there will be a further improvement in the food resources of milch-cattle. The introduction of soya bean, a legume rich in oils, will greatly enhance the supply of edible oil. In planning the nutrition of the whole world, the advisability of exporting oil seeds from a country grossly deficient in fats and oils, will, we hope, be determined by the FAO.

PROTEIN DEFICIENCY

Deficiency in total proteins, and more particularly in the proteins of high biological value, is India's most serious nutritional problem. This deficiency may not manifest itself in mortality and disease, but is evident in the slow rate of growth, reduced size of body, lack of efficiency and vitality. That this is actually the case is abundantly manifested by the condition of both men and cattle. Dr. Burns has correlated the amount of food and body weight in cattle of the different regions of India, and Radhakamal Mukerjee has made similar studies in human groups (see p. 15). It is evident that where cattle are ill fed and small in size, and milk production per head of human population is low, the human physique is poor. Average live weight of cattle and man is fairly closely correlated.*

Pulses and cereals are the chief source of vegetable proteins. Reduction in the area of cereals will reduce the quantity of proteins of this source slightly, but a 20 per cent. increase in pulses will make up the deficiency.

* Lack of adequate amount of calcium is also a contributory cause.

Rainfall in inches	Regions	CATTLE ¹			Daily milk production per head human population	MAN ²		
		Average live weight	Daily requirements per head			Regions	Average body weight	Calories intake
			Quantity available					
			Rough-ages dry	Concentrates				
		lb.	lb.	lb.	oz.		lb.	
Over 70	Assam ..					Assam		
	Bengal ..					Bengal		
	Madras—(C) ..					Madras		
	Malabar ..							
	S. Kanara ..							
	Bombay—(A) City ..	500	11	0.5	3.01		100 to 120	2,000 to 2,500
	Suburban ..		7.37	0.14				
	N. Kanara ..							
	Kolaba ..							
	Thana ..							
Ratnagiri ..								
30 to 70	Bihar ..					Bihar		
	Orissa ..					Orissa		
	U. P. ..					Eastern U. P.		
	C. P. ..							
	Bombay—(B) Ahmadabad ..	600	13	0.75	6.18	Western U. P.	120	2,500
	Baroch ..		9.52	0.19		Bombay	to	to
	Panchmahal ..						150	3,000
	Kaira ..							
	Surat ..							
	Madras—Major part excluding C & D ..							
Below 30	Madras—(D)... ..							
	Anantpur ..							
	Bellary ..							
	Cuddapah ..							
	Kurnool ..							
	Bombay—excluding A & B ..	700	15	1	12.22			
			15.7	0.38				
	Sind ..					Punjab	150	3,000
Punjab ..					N.W.F.P.	to 170	to 3,500	
N.W.F.P. ..								

¹ Adapted from Dr. Burns : Technological Possibilities of Agricultural Development in India.

² Adapted from Dr. Radhakamal Mukherjee : Population and Food Supply.

It is, however, the increase of proteins of high biological value, which is India's greatest need.

The Nutrition and Food Management Committee of the FAO have recognised that "the primary objective of the nations united in the Food and Agriculture Organization is to raise the level of nutrition throughout the world, to ensure not only that all people are freed from the danger of starvation and famine, but that they obtain the kind of diet essential for health." Our Food Policy should aim at 'abundant health,' and our goal should be 'the creation of healthy and vigorous population,' able to shoulder the burdens of peace and war.

Protective foods

Let us now deal with the foods of animal origin, "protective foods" and proteins of high biological value, provided by fish and flesh, eggs and milk. The requirement of these foods for 400 million human beings is estimated at 300 per cent. over and above the present supply.

The most important of the food resources of this category are fish. The extensive waters around the coast of India, vast estuarine areas, numerous rivers and canals, lakes and tanks provide almost unlimited possibilities for the production of fish. Fish may be described as the food ready-made for man to collect. The neglect to develop, nay even to control, the fisheries in India has been colossal. It is only under the stress of war-time food scarcity that the necessity of developing this valuable source of food has been recognized. It is encouraging to find that several Provinces and States as well as the Central Government have taken steps to develop the fishery resources of the country. Programmes of development include all aspects of the fish industry, and teaching and research. We can look forward with confidence to the full development of this source of food. An abundant and cheap supply of fish will solve the problem of a balanced diet for the enormous rice-eating population. No effort should be spared to develop fisheries.

Sheep, goats, pigs and poultry are well known sources of food. The Imperial Council of Agricultural Research are financing research on these animals, with a view to improving breeds and increasing the quantity of food produced from these sources. Among the smaller animals, a useful source of wholesome flesh is the rabbit. It multiplies very rapidly and grows quickly. In other countries rabbit breeding is an important industry, and it is a pity that in India nothing has been attempted so far, and this excellent source of very good food is being ignored.

In a country so short of food of animal origin as India, every source, however small, has to be tapped and the best use made of it. What is the place of wild life—birds and mammals, in the food resources of India? Several wild birds and mammals are eaten, and some are regarded as delicacies, but there is complete absence of information as to the volume of this source of food. Even the wildest guess is not possible. The only thing one is aware of being that the damage caused to cultivation by wild pigs and deer of sorts, is so serious in certain localities that vast areas have gone out of cultivation. Protection of crops and fruit against the ravages of birds is one of the difficult responsibilities of the farmer. This may be taken as an index of the quantity available.

Investigations carried out in America indicate the importance of wild life. It has been shown that where marshes have been reclaimed for cultivation, the benefit gained has not compensated for the loss sustained, through

the destruction of water fowl. We have approximately 200,000 square miles of forests. Can they not be stocked with eatable birds? There is immediate need for a thorough survey and population study of the wild life of India as a preliminary to a national planning of game improvement.

Cattle problem

Of the live-stock the most important are the cattle, and they occupy a unique position in the rural economy of India. They provide the draught animal for cultivation, contribute to the fertility of soil by providing farm-yard manure—the only manure readily available to the farmer. Cattle dung makes up the deficiency of fuel resources for household needs. Cows and buffaloes provide milk—a perfect food—and in a country where a large section of the population is vegetarian, the milk supply is of great importance. The cattle, finally, provide flesh for human consumption, and their hides, bones and horns are products of considerable value in industry*. Indeed the place of cattle in the economy of Indian farming is so fundamental that the ancients considered that the bull carried the earth on its horn, and they deified the cow. Paradoxical though it may appear, yet it is a fact that a stage has been reached when on the one hand cattle provide food for man and on the other compete with him for food. It is true that cattle mostly live on straw and stock—bye-products of grain production—yet the pressure of population has forced man to encroach upon pastures and break land for the cultivation of food crops with loss of fodder for cattle. The result is that to-day there is great scarcity of cattle feed. Cattle are underfed, inefficient, and too large a number has to be maintained. India possesses one third of the world's cattle population. Without adequate feeding, improvement in breeds is a hopeless task.

Burns estimates that the total number of bovine adults in British India is 107 million and the total feed available is 175 million tons of roughages and less than 4 million tons of concentrates. Ignoring the requirements of young stock, the deficiencies are : 50 million tons of roughages and 9 million tons of concentrates. Of the available food, work-cattle get the larger share, and milch-cows are starved.

The position is that in addition to an enormous human population the Indian soil has to carry a very heavy load of a large cattle population. Ill-fed and consequently inefficient cattle are a terrible drain on our resources. The Chinese and the Japanese have mostly eliminated cattle from their farm economy. They have replaced bullock labour by human labour; milk and milk products do not enter into their dietary and their protein requirements they satisfy by feeding on all sorts of animals.

What is the solution?

In 1940, there were in British India 49 million working bullocks and uncastrated males over three years of age, kept for work. All those who have studied the food and agricultural problem of India have advocated the urgent need of reducing the number of bullocks, so that the cows are better fed and the milk supply is thus increased. For instance, the Royal Commission on Agriculture in India, emphasized the "necessity of attention on all matters that will tend to decrease the number of bullocks required for cultivation". Sir John Russell followed in the same strain and said, "If it were feasible,

* In actual value (including the value of dairy products) the (livestock) industry contributes at a rough estimate about 1,000 crores of rupees to the agricultural income of the country, which has been assessed at a total of 2,000 crores of rupees.

the best course would be a large reduction in numbers of animals so as to bring live stock population more into line with the supplies of food, but this cannot be done rapidly. Some gradual reduction will no doubt come about by economic pressure as the grazing grounds become more closely settled for cultivation, and as the castration of scrub bulls becomes more commonly practised. Improvements in farm implements and particularly in the bullock cart, would reduce the need for so many bullocks in the village." Prof. Radhakamal Mukerjee also advocates the adoption of a "definite programme of reduction of cattle numbers".

The problem is how to reduce this number.

Improvement of farm implements, or bullock carts with ball bearings and pneumatic tyres, do not even scratch the surface of the problem. Co-operative use of inefficient bullocks is not a practical proposition, when on account of the shortness of season for the preparation of land, the available period for cultivation is limited. Small holdings will continue as long as there is no outlet for the rural population in industry. Utilising animal labour for cultivation and transport is a most wasteful method. It has been estimated that in many parts of India the work-cattle are employed for half the year, and yet they have to be maintained and fed throughout the twelve months. The Royal Commission have stated that bullock labour is a heavy item in crop production.

Mechanization

The *only* effective measure that will reduce the number of workcattle is mechanization.

Mechanization of agriculture has made revolutionary changes during the last few years. Here is a picture of a fully mechanized cotton farm in the U.S.A.

"Tractor-drawn equipment ploughs and cultivates the crop. Flame throwers kill the weeds. Airplanes dust the cotton with insecticides, and, a week before the cotton is mature, they apply a cyanamide compound which makes the leaves drop off. When the leaves are gone, the cotton picking machine moves in. A cotton picking machine can pick a thousand pounds of cotton per hour, instead of 15 pounds a man can pick. Such a machine works all day and then with headlight on it works all night."

The progress of mechanization of farming in Russia is a well-known story.

Mechanization in farming is usually associated with scarcity and high cost of labour. It has, however, another, and for India a more important, aspect. Mechanization may be adopted as a device to reduce demand on food resources. A bullock or a horse is to be fed from the produce of the land. A tractor runs on petrol or crude oil.

At the present time the aim in India should be to replace animal labour by machine and thus save food which is now consumed by the work-bullocks. What would be achieved as a result of such mechanization may be illustrated by taking an example from the U.S.A. "About 1920 there were 26 million horses and mules in the United States of America and by 1940 there were less than 16 millions. In 1919, there were 160,000 tractors, and by 1939, they had increased to 1,600,000. This has meant a release of 35 million acres of land the production of which was required to support work stock." Imagine what similar reduction in the number of bullocks would mean to the human population of India. The fodder thus saved and fed to cows

would bring about an immediate increase in the milk supply. Do we not know that a 60 per cent. increase in milk yield can be obtained by good feeding ? Further with an assured supply of fodder the breeds can be improved, resulting in increased efficiency of milch-cattle.

One of the post-war development plans is to take motor transport right into the heart of rural India, this will mean the replacement of bullocks now used for transport. There are schemes of hydro-electric development which will provide motive power for water-lifting, cane-crushing, corn-grinding, for which bullock power is being used at present. A very real step towards the reduction of the number of bullocks will be the introduction of tractors.

The present is the most appropriate time for launching a campaign for the mechanization of agriculture. The price of bullocks is high. There are thousands of trained mechanics, familiar with tractors and other power-driven machinery, who will be released from the army. The chief difficulty, however, is that tractors are not available, and designs suited to Indian conditions have not been determined.

In my opinion the first step that should be taken is to hold an exhibition of tractors and farm machinery on a very large scale, to which tractor manufacturers and producers of farm machinery should be invited from all over the world. This would enable agricultural experts and manufacturers to determine which models are most suited to conditions obtaining in India. The next step would be to establish a tractor manufacturing industry and a fully-equipped Institute for Research on Tractor Designs to guide such an industry. The first need of India is not luxury motor cars but sturdy tractors, of moderate size and moderate price, which run on cheap fuel.

It will not be possible for every individual farmer to own even a small tractor and have the minimum number of implements required for cultivation. The only possible method would be to undertake cultivation on contract basis. There may be difficulties in the beginning but if the charges are moderate and the work is done efficiently and expeditiously the cultivators will soon appreciate the advantages. The cost of cultivation could be substantially reduced by providing cheap fuel. For instance, no tax should be levied on petrol or crude oil or any other fuel used for agricultural purposes. Further it would be necessary to establish chains of repair stations.

It is a mistaken idea that co-operative farming should precede the use of tractors and other power machinery. In fact the introduction of tractors will inevitably result in co-operative farming. When a small holder finds that his land can be cultivated cheaply and efficiently without his keeping bullocks, he will join in a co-operative scheme of farming. The farmer is not as conservative as he is imagined, but is alive to gains that he can get.

INCREASED PRODUCTION OF VEGETABLES AND FRUITS

The consideration of increased production of vegetables and fruit need not delay us. By proper management, use of good seed, and plants of high-yielding varieties, production of these useful and necessary foods can be greatly enhanced from the existing area. A system of cropping in which orchards are intercropped with fodder or vegetables, will mean better use of the land. For instance, fodder could be grown in a vineyard, an orange grove or a mango orchard. Carefully-planned trials alone will determine

the most rational use of land, as various conditions will determine what can be achieved, and these conditions vary from locality to locality.

CONCLUSION

To sum up : A national crop planning should be based on the best and most efficient utilization of land and other resources for social needs. The first social need is food. It is possible to evolve, for the various parts of the country, cropping schemes which will result in greater production of carbohydrates from smaller areas, than is the case at present. In any such scheme tubers will play an important part, and the area under cereals will have to be reduced. Acreage released from cereals can be devoted to pulses, oil-seeds, fodders, an increased production of which is necessary for obtaining well-balanced diet. The increased food for milch-cattle, both in roughages and concentrates, which will result from such a cropping scheme, will make up our existing deficiencies in milk—a most necessary 'protective food'. The introduction of more legumes, i.e., pulses as well as fodders, will enrich our soils. A reduction in the number of bullocks by encouraging the use of tractors and motor transport, and the introduction of machinery driven by cheap electric power, will release much fodder and enable us to improve our breeds of milch-cattle, with a consequent increase in milk production. (In appendices a model scheme of crop-planning has been worked out.)

All this is possible and we have the knowledge to do it, but as the Hot Springs Conference stated : "It requires imagination and firm will on the part of each government and people to make use of that knowledge."

FOOD TECHNOLOGY

The available resources of food can yield better results, if their nutritional values are conserved, and not destroyed in processing and preparation for consumption. One need only mention the case of eating over-milled rice. There is not only loss of valuable food rich in proteins, but the additional disadvantage of the consumer suffering from deficiency diseases. Preservation of food, in a satisfactory manner, is an essential part of food economy. A great deal of wastage, which can be avoided, occurs during transit, particularly in the case of fruit, fish, and such articles of diet as putrefy quickly. Large quantities of food grains and other food products are consumed and spoiled by rodents and insects. It is necessary that our transport system be improved through refrigeration, and cold storage developed extensively for all types of foods, which must be kept at a low temperature for safe preservation. Improved storage is one of the methods of avoiding damage to grain. Dehydration of food products is of incalculable value in food preservation and distribution. It is particularly necessary for bulky foods, such as tubers. It reduces bulk and makes for low cost of transport and distribution. From liquid milk to potatoes every type of food can be successfully dehydrated. As the technique improves it will be possible to preserve all the good qualities of fresh food in dehydrated commodities.

As far as India is concerned, fortification of the common articles of diet, with all the ingredients necessary for full health is an urgent necessity. Starch from cassava, fortified with proteins, vitamins, minerals and other useful ingredients, and pre-cooked to a suitable stage, may greatly help to solve the nutritional problems of, for instance, Travancore. Modern development in food technology has shown what can be done with cotton-seed meal in making it acceptable to man as a highly nutritional food. Cotton-seed flour is being used in America in such quantities that the supply

cannot meet the demands of bakeries and biscuit firms. Cotton-seed flour is twenty times as nutritious as potato, and contains 50 per cent. of proteins.

Chemists have produced rayon, nylon, plastics, and there seems to be no reason why they cannot produce artificial rice from tuber starch. This rice may be a perfect food containing all the necessary requisites of an excellent diet, it may have a flavour which appeals to the human palate, and it may be cheaply produced in such form that it can be prepared for a meal in an easy manner.

Food yeast from molasses is known to contain 50 per cent. proteins of high biological value and the important vitamin B₁. Our sugar-industry can supply huge quantities of molasses for the manufacture of yeast. Yeast mixed with flour will add valuable protein to a diet containing starch. Yeast can be grown on several other media and there are tremendous possibilities of large scale production.

Much headway has been made during the war in the production of shark liver oil which satisfies a great demand. Further increased production is awaited.

It is now possible to produce vitamin concentrates and synthetic vitamins on a commercial scale. It should be possible to make them available to people of the lowest income group.

The production of amino acids, satisfying demands of the human body, is an achievement of modern science, and paves the way for further achievements in this direction. The day is not far off when, in the words of the Earl of Birkenhead, "Synthetic foods and the production of animal tissue *in vitro* will finally set at rest those timid minds which prophesy a day when the earth's resources will not feed her children." This is possible, but much research is needed to attain such an end. For our immediate needs there is a strong case for a fully-equipped National Institute of Food Technology.

THE FARMER

National crop planning should be based on the best and most profitable utilization of land and other resources for social needs, and the individual profit motive should be eliminated. That would be the ideal condition. But as things are, the object of the farmer, in his own interest, is *not* to obtain the largest yield possible per acre, but to obtain the largest *economic* yield. As elsewhere in business, there is a clash between social needs and individual interests. There have been several instances when valuable foods have been destroyed to serve economic ends, and to make it worthwhile for the farmers to grow certain essential crops. A new orientation is needed in our rural economy.

So far the farmer has not received the attention he deserves. There is need for a proper sociological study of the Indian village life and the influence of modern trends on this life. The standard of living of the largest body of consumers—the growers of crops—has to be raised. What is this standard of living? Which is the best philosophy? Plain living and high thinking, or increasing one's wants and seeking the satisfaction of all these? A man who is a believer in plain living is a poor consumer. What part does he play in a world where circulation of wealth is the test of a progressive civilization? It is not possible to go into all these questions, but the questions are important. There is a need for an Institute of Sociology to study rural problems.

FUNDAMENTAL IMPORTANCE OF PURE SCIENCE

Before I close, I feel that it is necessary to sound a note of warning. It is necessary, because I have laid stress on the application of scientific knowledge to food production—the primary need of man. I am aware that much agricultural improvement has resulted from empirical methods of practical farmers and stock breeders. Many useful varieties of crops, fruit trees and vegetables have been produced, many well-known breeds of animals evolved. Nevertheless, to-day it is the scientific method which will give results of value. The preliminary stage of simple human effort has long past. The scientific method aims at 'studying the soil, the plant and the animal in order to learn as much as possible about them, not with the idea of greater production but of gaining new knowledge' (Russell). It is on this foundation of sound knowledge that the structure of practical achievement can be raised. There is a tendency to expect of scientists *quick results of practical value*. We are often accused of carrying on pure research. Even the Imperial Council of Agricultural Research has brought 'Development' within its orbit and there is a danger that this 'development' may sound the death knell of 'research.' It will be a sorry day for this country when the tradition of knowledge for the sake of knowledge disappears. We must safe guard ourselves against such a tendency. There should be abundant opportunities for scientific workers in India to build up a sound body of knowledge, and then results of practical value will necessarily follow. It is rare to find a man who will pursue a line of research for the sake of enlarging the bounds of knowledge, but there are many who are keen to apply what is already known in order to achieve results of use to man.

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APPENDIX I

Acreage, production, and quantities of different ingredients of food, in crops of different categories in British India. (Average for 5 years ending 1938-39).

Crops	Area million acres	Percent- age to total	Produc- tion million tons	Yield per acre			Calories per acre ('000)
				Pro- teins lb.	Carbo- hydrates lb.	Fats lb.	
Cereals ..	156.39	64.09	47.11	69	531.5	10	1,132
Pulses ..	26.74	10.97	6.28	105	312	17.7	831
Edible oil seeds ..	17.63	7.22	4.02	125.7	115	204	1,268
Sugar-cane ..	3.61	1.49	4.97 (gur)	12.3	2,915	3	5,343
Other food crops	6.99	2.87					
Cocoanut ..	0.66	0.27					
Fodder crops ..	10.40	4.26					
Cotton ..	16.67	6.01	(Seed has almost the same composition as other oil seeds).				
Other fibres ..	3.31	1.36					
All other crops ..	3.65	1.46					

For details refer to the Famine Inquiry Commission Report, 1945.

APPENDIX II

A TENTATIVE SCHEME OF IMPROVED FOOD PRODUCTION

Proteins, Carbohydrates and Fats in cereals, pulses, tubers, oilseeds and milk per 100 acre cultivated area

	Under existing distribution of crops (Average of 5 years ending 1938-39)					Under proposed distribution of crops					Remarks
	Cereals	Pulses	Tubers	Oilseeds	Total	Cereals	Pulses	Tubers	Oilseeds	Total	
Area. (acres)	64	11		7	82	45	13	5	14	77	Balance 5 acres under fodder, increasing the fodder area to 9.26
Yield per acre (lbs.)	715	524	10,000	511	8,750	..	..	..	..	..
Protein (lbs.)	4,422	1,156		*880	5,459	3,110	1,366	400	*1,761	6,637	
Carbohydrate (lbs)	34,018	3,432		*805	38,255	23,919	4,057	12,219	*1,610	41,804	
Fat (lbs.)	641	194		1,431	2,266	450	230	1	2,862	3,543	
Calories (in '000s)	72,448	9,141		8,876	90,465	50,940	11,203	34,000	17,752	113,895	
Milk Yield	per 100 acres				11.5 tons	Increased production by 100 per cent. through better feeding, and improvement in breeds.Fodder is more than doubled, because of larger area and reduction of bul-look population.					23 tons
Protein (lbs.)	..	..	..	..	979						1,968
Carbohydrate (lbs.)	..	..	..	..	1,262						2,524
Fat (lbs.)	..	..	..	..	1,417						2,324
Calories (in '000s)	..	..	..	..	9,837						19,674
Total available for human consumption (Population 140 per 100 acres)						28 per cent. of animal protein					
Protein (lbs.)	..	..	..	..	5,558	..	..	..	..	6,834	plus 23%
Carbohydrate (lbs.)	..	..	..	..	38,712	..	..	..	..	44,328	12%
Fat (lbs.)	..	..	..	..	3,683	..	..	..	..	6,377	73%
Calories (in '000s)	..	..	..	..	100,802	..	..	..	..	133,569	33%

*Not available for human consumption, used for cattle feed.

plus 23%
12%
73%
33%

SECTION OF MATHEMATICS

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RECENT ADVANCES IN DIFFERENTIAL GEOMETRY OF RULED SURFACES

(Delivered on 3 January, 1946)

INTRODUCTION

Like most other branches of knowledge, the subject of Geometry arose originally in response to man's practical needs. The earliest geometrical work consists merely of a number of crude rules for the mensuration of various simple geometrical figures. This crude beginning was developed by the ancient Greeks into the Science of Geometry. The geometry of practically all predecessors of Descartes was mostly synthetic in character. Geometrical figures were considered directly without the aid of Algebra. In 1637, Descartes hit upon the concept of co-ordinates and developed Analytical Geometry. With the help of coordinates, Algebra and Geometry which had so far developed in two separate water-tight compartments got fused into one. From the time of Descartes on, the developments of Geometry and Analysis have been closely connected. The introduction of the Differential and Integral Calculus by Newton and Leibnitz about 50 years later (1687) greatly increased the scope of Analytical Geometry and gave rise to the Differential Geometry of curves and surfaces. Writers on Differential Geometry in the earlier part of the 18th Century dealt mostly with plane curves. In 1775, Monge considered the theory of space curves and got particularly interested in developable surfaces. From the theory of curves came a natural transition to the theory of surfaces, in the geodesic problem, i.e., in the problem of finding the shortest path on a surface between two of its points. Euler was the first to note that a cone and cylinder can be developed on a plane and that these are ruled surfaces. Meusnier, Dupin and Cauchy made further advances. Cauchy's beautiful methods might have led to important results, but just then Gauss introduced a new technique which inaugurated a singularly fruitful method for handling problems on differential geometry of surfaces. Gauss recognised the fact that the co-ordinates of points on any surface can be expressed as functions of two independent parameters and took the great step of using this fact in a systematic fashion as a line of approach to the development of the theory of surfaces. The great freedom allowed in the choice of the parametric curves in Gauss' method brought about a great progress in Differential Geometry. Lamé, Beltrami, and Graustein developed methods for finding invariant parameters. The technique of Gauss was in every way admirable for the study of surfaces in three dimensional space and the two-parameter manifolds, such as rectilinear congruences. But the tendency in mathematics in recent years has been towards the greatest possible generalization, and when it came to the study of such subjects as m -dimensional manifolds in n -space, the Gauss notation ceased to be suggestive. For such generalization two things were necessary, a better notation and a further development of invariant expressions which depend

upon the nature of the manifold and not on the type of coordinates used. In 1844, Grassmann introduced the idea of geometry in n -dimensional space, a point of such a space being determined by n coordinates. In 1846, Plücker took a long step by taking as fundamental element of space the straight line which is determined by four independent coordinates leading to four dimensional line-geometry.

In 1892, Ricci and Levi-Civita developed the theory of the Absolute Differential Calculus. Taking the distance element as $ds^2 = g_{ij} dx^i dx^j$, Riemann developed an n -dimensional geometry known as Riemannian Geometry. Weyl and others developed a geometry without using this quadratic form which is called Non-Riemannian Geometry. It is thus possible to develop geometries based on different connexions, that is, different coefficients of structure, just as various non-Euclidean geometries were developed by Lobachevski, Bolyai, Riemann, Cayley, Klein and others by changing the parallel assumption. Important work in this direction has been done by Cartan and Kosambi.

The development of the various types of geometries in the latter part of the nineteenth century is mainly due to the important earlier researches in Algebra and the theory of Continuous Groups developed by Lie. Klein's discovery that every geometry is determined by a group of transformations has been of far reaching consequences. Cartan has shown how it is possible to develop any differential geometry upon the basis of the theory of finite transformation groups. Further generalization gave birth to the study of Topology on which fundamental researches have been carried by Alexandroff, Hopf, Alexander, Hausdorff, Kuratowski, Hilbert, Veblen, Brouwer, Eilenberg, Moore, Vaidyanathaswamy and others. Recently considerable work has been done on various topics in Euclidean differential geometry, namely, Kinematical methods, special mapping problems, special curves and surfaces, nets of curves, webs, Rectilinear Congruences and Complexes, etc.

The theory of Ruled Surfaces has been studied by various methods. The algebraic geometry method by Edge¹, Welchman², Woodcock³ and Godeaux⁴, the projective differential geometry method by Wilczynski⁵, and Weitzenböck⁶, the kinematical method by Rowe⁷, Lobell⁸, Krames⁹ and Strubecker¹⁰ need special mention. I shall, however, deal with the differential geometry of Ruled Surfaces and Rectilinear Congruences only and shall review the advances made during the last fifteen years.*

RULED SURFACES

A surface which can be generated by the motion of a straight line is called a 'ruled surface'. The infinitude of straight lines which thus lie on the surface are called its 'generators'. Ruled Surfaces are of two types, viz., developable surfaces or torse and skew surfaces or scrolls. Developable surfaces are those ruled surfaces which can be developed into a plane. Skew surfaces are those ruled surfaces which are not developable. We shall restrict ourselves to skew surfaces and shall use the term 'ruled' to specify such surfaces. We shall assume the generators to be real.

Let the equations of a ruled surface be $x=p+lu$, $y=q+mu$, $z=r+nu$, where p, q, r are the coordinates of a point M on a curve on the surface called the directrix, expressed in terms of the arc v of the directrix measured from a fixed point O on it, l, m, n also expressed in terms of v are the

* It is with deep regret that many allied interesting investigations are of necessity left out on account of limitations of space and lack of up-to-date information due to war conditions.

direction cosines of the generator that passes through M, and u is the distance measured from M along the generator through M to any point P(x, y, z) on it.

Properties of the line of striction. The equation of the line of striction of the ruled surface is $u = -\Sigma l' p' / \Sigma l'^2$, where accent denotes differentiation with regard to v . Richmond¹¹ has proved from geometrical considerations that if at each point of a curve C on a surface, a tangent to the surface is drawn, and these tangents generate a ruled surface of which C is the line of striction, then, if each tangent is turned through a constant angle α about its point of contact in the tangent plane, the new set of tangents also form a ruled surface with C as a line of striction. The author¹² has proved this result analytically. Thus there is an infinite number of ruled surfaces having a common line of striction and having the same tangent plane at each point of the line. In particular, if the constant angle α is a right angle, we arrive at the ruled surface known as the "Strictionsband". From the above considerations, it easily follows that the Strictionsband of the Strictionsband of a ruled surface is the same ruled surface back again. He has also shown that a ruled surface whose line of striction is any given curve C can be easily constructed as follows:—Draw any developable through the curve C. Develop it into a plane so that the curve C becomes a plane curve C', say. At each point of C' draw a line in an arbitrary fixed direction. When the plane is deformed back into the original developable, these lines will generate a ruled surface with the required property.

Ramamurti and Srinivasiengar¹³ have worked on the lines of striction on a quadric. They have considered the metrical specializations consequent to the metrical definition of the line of striction and a few allied problems. Ramamurti¹⁴ has given an invariant specification of the lines of striction, and the associated (3, 1) correspondences.

Properties of the generators and their generalizations. Weatherburn¹⁵ has given several new properties of the generators of a ruled surface. By taking the generators as the parametric curves $v = \text{const.}$ and their orthogonal trajectories as the curves $u = \text{const.}$, he has used the Mainardi-Codazzi relations

to obtain the formula $\frac{\delta}{\delta u} (\sqrt{-k}) = -2\gamma \sqrt{-k}$, where k and γ stand for the

Gaussian curvature and geodesic curvature respectively. The author¹⁶ has obtained this formula by an independent method without any reference to Mainardi Codazzi relations and has obtained a further result that if the mean curvature varies inversely as the distance function along an asymptotic line and the total curvature is constant along any orthogonal trajectory of the asymptotic lines, then the surface is ruled.

Referring any general surface to asymptotic lines and their orthogonal trajectories as the parametric curves $v = \text{const.}$ and $u = \text{const.}$ and transforming the Mainardi-Codazzi relations, Rangachariar¹⁷ has obtained the following generalizations of the properties of the generators of a ruled surface:—(i) Along an asymptotic line of a ruled or a minimal surface, the angular acceleration of the tangent plane is equal to $\pm 2\sqrt{-k} \cdot \gamma$ and conversely, if the angular acceleration is $2\sqrt{-k} \cdot \gamma$, the surface is either ruled or minimal. (ii) The total curvature along an asymptotic line of a ruled or a minimal surface varies as the fourth power of the distance function. And conversely, if along an asymptotic line, the total curvature varies inversely as the fourth power of the distance function, the surface is either ruled or minimal. (iii) If the point moves with unit speed along an asymptotic line, the rate of change of $\psi^2 \sqrt{-k}$ is equal to the product of the first curvature, the square of the

distance function and the curvature of the asymptotic line, where ψ denotes the distance function. (iv) Along an orthogonal trajectory of an asymptotic line of a minimal surface the total curvature varies inversely as the fourth power of the corresponding distance function.

Curved asymptotic lines. Osculating Quadrics. Picard¹⁸ has shown that if the generators of a ruled surface belong to a linear complex, then the curved asymptotic lines can be determined by quadratures. Buhl¹⁹, Goursat²⁰, Hayashi²¹, Srinivasiengar²², and others have considered the determination of asymptotic lines of some particular kinds of ruled surfaces by quadratures. The author²³ has approached the problem in a different way. He has examined a number of cases under which the equation of the curved asymptotic lines,

$\frac{du}{dv} + \frac{\lambda}{2\delta} + \frac{\mu}{2\delta}u + \frac{\nu}{2\delta}u^2 = 0$, which is a Riccati's equation, can be integrated,

and has given their geometrical meanings. He has also obtained various properties²⁴ of the curved asymptotic lines. The equation of the curved

asymptotic lines can be written as $\frac{du}{dv} = \alpha + \beta u + \gamma u^2$ where $\alpha = -\frac{\lambda}{2\delta}$, $\beta = -\frac{\mu}{2\delta}$

$\gamma = -\frac{\nu}{2\delta}$. The tangent to the asymptotic line at the point (u, v) is given by

$$\frac{x-p-lu}{p'+l'u+(\alpha+\beta u+\gamma u^2)l} = \frac{y-q-mu}{q'+m'u+(\alpha+\beta u+\gamma u^2)m} = \frac{z-r-nu}{r'+n'u+(\alpha+\beta u+\gamma u^2)n}.$$

When u varies, the point (u, v) describes a generator and the tangents form a quadric. Also since the generator and the tangent to the asymptotic line are two distinct lines that touch both the quadric and the ruled surface, it follows that the quadric generated by the tangents to the curved asymptotic lines at their points of intersection with a generator touches the ruled surface all along that generator. Such a quadric has been called by Bianchi²⁵, the osculating quadric of the ruled surface along that generator. The author²⁶ has developed a systematic study of osculating quadrics, obtaining a chain of results. He has found the condition that the osculating quadric of a ruled surface be equilateral, i.e., may have three mutually perpendicular generators. The condition takes the simple form $\Sigma p''l' - \Sigma p'l'' = 0$, when the base curve is an orthogonal trajectory of the generators. The condition retains this form when v is not the arc but any arbitrary parameter, and is automatically satisfied for a right conoid whose equations are $x=u$, $y=v$, $z=kv$. Hence a right conoid is the ruled surface such that all its osculating quadrics are equilateral. When the base curve is not an orthogonal trajectory of the generators but is any arbitrary curve, the condition that the ruled surface may have equilateral osculating quadrics takes the form $\Sigma p''l' - \Sigma p'l'' + 2(\Sigma lp')(\Sigma l'' - \Sigma l'^2) = 0$. He²⁷ has shown that out of the ∞^3 osculating quadrics of a ruled surface, ∞^2 are equilateral. The osculating quadric becomes a paraboloid when the generators of the ruled surface are parallel to a plane. The conoid is a special case. If at points, along a generator of a ruled surface, tangent lines are drawn to the orthogonal trajectories of the curved asymptotic lines, then these lines generate a quartic ruled surface touching the given ruled surface. The quartic reduces to a cubic whenever the generators are parallel to a plane. (The right helioid is excluded from this theorem, since it is a minimal surface).

A new geometrical meaning of Laguerre's function. By taking a curve on a given surface as the base curve, x, y, z the coordinates of a point P on the base curve, and X, Y, Z the direction cosines of the normal to the surface at P,

the author has established by two entirely different methods²⁸ that the expression, $\Sigma X''x' - \Sigma X'x''$ is exactly equivalent to the Laguerre's function L'

viz., $\frac{d}{ds} \left(\frac{1}{R} \right) + \frac{2}{\tau} - \frac{1}{\gamma}$ where R, τ, γ are the radii of normal curvature, geodesic

torsion and geodesic curvature of the curve respectively. He has thus discovered a new geometrical meaning of Laguerre's function, viz., that its vanishing along a curve on a surface is the condition that the osculating quadric of the ruled surface formed by drawing normals to the surface along the curve be equilateral. In particular, if the curve on the surface be a geo-

desic, then $\frac{1}{\gamma} = 0$ and also $\frac{1}{R} = \frac{\cos \phi}{\rho} = \frac{1}{\rho}$ since $\phi = 0$ for a geodesic; therefore

if $L' = 0$ along the curve, we have ρ stationary. Hence if the ruled surface formed by drawing normals to a surface along a curve on it has equilateral osculating quadrics and if the curve is a geodesic, the circular curvature of the curve will be stationary. He has also shown that:

If a ruled surface R having equilateral osculating quadrics be taken, and if the ruled surface formed by the normals to R along an orthogonal trajectory of its generators also has equilateral osculating quadrics, then the orthogonal trajectory is of constant curvature. Conversely, if a ruled surface R with equilateral osculating quadrics has an orthogonal trajectory C of its generators which has constant curvature, the normals along C generate a second ruled surface with equilateral osculating quadrics except (possibly) when C is an asymptotic line on R .

If two ruled surfaces intersect along a common orthogonal trajectory of their generators at a constant angle, and if this trajectory is of constant curvature, then neither or both have equilateral osculating quadrics. Conversely, if two ruled surfaces, both having equilateral osculating quadrics, intersect at a constant angle along a common orthogonal trajectory, then this trajectory has constant curvature. Otherwise:—if a ruled surface with equilateral osculating quadrics is formed by normals to a curve of constant curvature, we get a second ruled surface of the same kind if we rotate each generator through a constant angle in the normal plane of the curve. Bouligand²⁹ has discussed the curved asymptotics of a ruled surface by taking it in the form $x = az + p$, $y = bz + q$, where a, b, p, q are functions of a parameter t .

Mayer³⁰ has given simple applications to the general theory of ruled surfaces by considering the system of curved asymptotic lines and the couple of the flecnodal lines of the surface.

Fubini³¹ has found all ruled surfaces whose curved asymptotics are projective to each other and has shown that each one of these asymptotic curves belongs to a linear complex. He has also shown that the points on the curved asymptotics corresponding in the projectivity lie on one and the same ruling of the surface and has proved the converse theorem, viz., 'if every curved asymptotic of a ruled surface belongs to a linear complex, these asymptotics are projectively related.'

Deformation of ruled surfaces. Among surfaces that are subjected to deformation special interest attaches to the class of ruled surfaces. This problem seems to have been considered first by Minding and later by Bonnet and Beltrami. B. M. Sen³² has pointed out distinction between applicability and deformation of one surface to another surface. He has shown

that a surface may be applicable to a given surface but not mutually deformable to it. The author³³ has pointed out several instances of ruled surfaces which though applicable to a given ruled surface are not mutually deformable to it and has verified that for Beltrami's associated ruled surface with parallel generators, L , M , N , the fundamental magnitudes of the second order have opposite signs.

While considering the general problem of deforming a ruled surface into another ruled surface in such a way that the deform of a given curve C on the original surface shall possess a certain property on the deformed

surface, Forsyth³⁴ has obtained the two equations $\frac{\sin\phi}{\rho} = -\theta' - \frac{B}{\sin\theta}$,

$$\text{and} \quad A - B^2 = \left[\frac{\cos\theta}{\rho} - \frac{\sin\theta\cos\phi}{\sigma} + \frac{d}{dv} \left(\sin\theta\sin\phi \right) \right]^2 \\ + \left[\frac{\sin\theta\sin\phi}{\sigma} + \frac{d}{dv} \left(\sin\theta\cos\phi \right) \right]^2.$$

From the first equation he has deduced that $\frac{\sin\phi}{\rho}$ is an invariant, but he

has not considered the second equation any further. The author³⁵ has shown that the second equation on simplification leads to a new invariant, $K_n \cos\theta + \tau_g \sin\theta$, where K_n and τ_g are the normal curvature and the geodesic torsion of the curve, and θ is the angle which the generator makes with the tangent to the curve. He has established this result by vector methods also. With the help of this invariant he has obtained sufficient conditions for ruled surfaces to be applicable.

Darboux³⁶, Bianchi³⁷, Goursat³⁸, Haag³⁹, and others have investigated the problem of infinitesimal deformation of a ruled surface. The general problem of infinitesimal deformation of any surface has been considered by the author⁴⁰ and the results have then been applied to the case of a ruled surface. It is shown that with the help of a device found by Haag the infinitesimal deformation of a ruled surface can be immediately deduced from that of a general surface worked out by Darboux.

RECTILINEAR CONGRUENCES

A rectilinear congruence is a two-parameter system, i.e., a double infinitude of straight lines. Up to the middle of the nineteenth century systems of lines in space were generally treated by the aid of Plücker-coordinates. This method was quite suitable for obtaining projective properties but for metrical problems it was not very fruitful. Kummer⁴¹ was the first to make a departure. He developed the general theory of rectilinear congruences with the help of two quadratic differential forms now known as Kummer's forms. Sannia⁴², Zindler⁴³ and others developed this technique further.

Let a surface S which is cut by all the lines of the congruence be taken as the surface of reference or the Director surface. Let $M(x, y, z)$ be a point on S and let the directioncosines of the ray which passes through M be X, Y, Z , so that $x, y, z; X, Y, Z$ are functions of the two parameters u and

v of the surface. Let t be the distance of a point $P(\xi, \eta, \zeta)$ on the ray, measured from M , then the equations of the rectilinear congruence are

$$\xi = x + tX, \eta = y + tY, \zeta = z + tZ.$$

Corresponding to any curve on the surface of reference there is a ruled surface formed by the lines of the congruence which meet the curve. Thus a curve $\phi(u, v) = 0$ on the surface of reference defines the corresponding ruled surface of the line congruence, and a differential equation of the form

$$\frac{dv}{du} = F(u, v) \text{ defines a family of ruled surfaces of the line congruence.}$$

Let a unit sphere be drawn with any point O as centre and let lines be drawn through O parallel to the rays of the congruence, each line cutting the surface of the unit sphere in a point which is called the spherical representation of that ray. The locus of the spherical representations of the rays of the congruence is thus a curve on the unit sphere which is called the spherical representation of the congruence. The linear element $d\sigma$ of the spherical representation or else the infinitesimal angle between two consecutive lines of the congruence, whose direction cosines are X, Y, Z and $X+dX, Y+dY, Z+dZ$, is given by $d\sigma^2 = dX^2 + dY^2 + dZ^2 = Edu^2 + 2Fdudv + Gdv^2$, where $E = \sum X_1^2$, $F = \sum X_1 X_2$, $G = \sum X_2^2$.

The two quadratic forms used by Kummer are

$$\sum dX^2 = Edu^2 + 2Fdudv + Gdv^2, \text{ and}$$

$$\sum dx dX = edu^2 + (f+f')du dv + gdv^2,$$

$$\text{where } e = \sum X_1 x_1, f = \sum X_1 x_2, f' = \sum X_2 x_1, g = \sum X_2 x_2,$$

the suffixes 1 and 2 denoting differentiations with regard to u and v respectively. The two quadratic forms used by Sannia are

$$Edu^2 + 2Fdu dv + Gdv^2, \text{ and } \delta du^2 + 2\delta' du dv + \delta'' dv^2,$$

$$\text{where } \delta = \frac{Ef' - eF}{\sqrt{EG - F^2}}, \quad 2\delta' = \frac{Eg - Ge + F(f' - f)}{\sqrt{EG - F^2}}, \quad \delta'' = \frac{Fg - Gf}{\sqrt{EG - F^2}}.$$

The distance to the line of striction of the ruled surface through a ray l is given by

$$t = - \frac{edu^2 + (f+f')dudv + gdv^2}{Edu^2 + 2Fdudv + Gdv^2}. \text{ The values of } \frac{dv}{du} \text{ for which } t \text{ is}$$

maximum or minimum, which define the two principal surfaces through the line l , are given by

$$\begin{vmatrix} Edu + Fdv & Fdu + Gdv \\ edu + \frac{1}{2}(f+f')dv & \frac{1}{2}(f+f')du + gdv \end{vmatrix} = 0.$$

The maximum or minimum values of t are given by

$$(EG - F^2)t^2 + [Eg + eG - (f+f')F]t + [eg - \frac{1}{4}(f+f')^2] = 0.$$

The points on l corresponding to the limiting values of t are called the 'limit points' of l , and the tangent planes to the principal surfaces at the limit points are called the principal planes. The principal planes are at right angles and the principal surfaces are represented on the unit sphere by an orthogonal system.

The two curves on the surface of reference which define the developable surfaces of the congruence through l are given by

$$\begin{vmatrix} Edu + Fdv & Fdu + Gdv \\ edu + fdv & f'du + gdv \end{vmatrix} = 0,$$

or $\delta du^2 + 2\delta' dudv + \delta'' dv^2 = 0$. The distances from M of the two points on l (called the focal points) where l touches the edges of regression of the two developables containing l are the two values of ρ in the equation

$$\rho^2(EG - F^2) + \rho(Eg + eG - Ff' - Ff) + eg - ff' = 0.$$

The tangent planes to the developable surfaces at the focal points are called the focal planes. The point midway between the limit points of l is also midway between the focal points of l and is called the middle point of l . The locus of the middle points of all the rays is called the 'middle surface' of the congruence. The distance between the focal points is never greater than the distance between the limit points so that the focal points lie between the limit points. The focal planes are symmetrically placed with respect to the principal planes, so that the planes bisecting the angles between the focal planes also bisect the angles between the principal planes.

The parameter of distribution P of the ruled surface is given by

$$P = \frac{\delta du^2 + 2\delta' dudv + \delta'' dv^2}{Edu^2 + 2Fdu dv + Gdv^2}.$$

The two surfaces for which P is maximum or minimum are called 'surfaces of distribution' or 'distributive ruled surfaces'. These surfaces have also been called surfaces of curvature by Zindler⁴⁴ and 'mean ruled surfaces' by Eisenhart⁴⁵, Burgatti⁴⁶, and Cifarelli⁴⁷. The curves on the surface of reference which define the mean ruled surfaces are given by

$$\begin{vmatrix} Edu + Fdv & Fdu + Gdv \\ \delta du + \delta' dv & \delta' du + \delta'' dv \end{vmatrix} = 0.$$

The maximum and minimum values of P are called the 'Principal parameters of distribution' and are the values of P in the equation

$$P^2(EG - F^2) + P(-E\delta'' - G\delta + 2F\delta') + (\delta\delta'' - \delta'^2) = 0.$$

The total parameter and the mean parameter of the congruence are defined as

$$k \equiv P_1 P_2 = \frac{\delta\delta'' - \delta'^2}{EG - F^2}, \text{ and } h \equiv P_1 + P_2 = \frac{E\delta'' + G\delta - 2F\delta'}{EG - F^2}.$$

The spherical representations of the mean ruled surfaces bisect the angles between the spherical representations of the principal surfaces and hence also the angles between the spherical representations of the developable surfaces.

Families of ruled surfaces through a line of the congruence. Starting from Sannia's two quadratic forms, Ogura⁴⁸ has obtained interesting results about the families of ruled surfaces through a line of the congruence. He

has shown that repeated applications of the operation of forming the Jacobian with Sannia's two forms f and ϕ leads to only five distinct families of ruled surfaces through a line l of the congruence, viz. (i) surfaces whose spherical representations are minimal lines, (ii) developable surfaces, (iii) surfaces of distribution, (iv) Principal surfaces and (v) characteristic surfaces, whose equations respectively are $f=0$, $\phi=0$, $J(f,\phi)=0$, $J(f, J(f, \phi))=0$, $J(\phi, J(f, \phi))=0$. He has also shown that the ruled surfaces whose spherical representations are minimal lines, the surfaces of distribution, and the principal surfaces form a cycle in the sense that the central planes (for any line of the congruence) corresponding to any one of these three surfaces are the double planes of the involution determined by the corresponding central planes of the other two, and that a similar result holds good for the developable surfaces, the surfaces of distribution and the characteristic surfaces. He⁴⁹ has proved algebraically the following general result:—If successive Jacobians be formed from the two binary quadratic forms

$$f_1 \equiv a_1x^2 + 2b_1xy + c_1y^2, f_2 \equiv a_2x^2 + 2b_2xy + c_2y^2,$$

then the five forms $f_1, f_2, J(f_1, f_2), J(f_1, J(f_1, f_2)), J(f_2, J(f_1, f_2))$ form a complete system in the sense that any other successive Jacobian is equal to one of these five forms save as to a constant multiple. From this general result he has deduced that the five families of ruled surfaces form the complete system. This result has also been proved geometrically by Hayashi.⁵⁰ The author⁵¹ has given a simpler method for obtaining this result by considering pairs of points on a conic instead of the quadratic forms to which they correspond.

Comparison of Sannia's theory of line congruences with Gauss' theory of surfaces. Kummer⁵² was the first to note the relation between the theory of line congruences and Gauss' Theory of surfaces. He mentioned the analogy between Hamilton's formula $p = p_1 \cos^2 \theta + p_2 \sin^2 \theta$ and Euler's formula

$$\frac{1}{R} = \frac{\cos^2 \theta}{R_1} + \frac{\sin^2 \theta}{R_2}.$$

Sannia⁵³ has mentioned the analogy between the total

and mean curvatures of the surface and the total and mean parameters of the congruence, and some other analogies. The author⁵⁴ has pointed out that the five families of ruled surfaces through a line of the congruence found by Ogura correspond in Gauss' Theory to the five families of curves on a surface, viz. Null lines given by $\psi_1 \equiv \bar{E}du^2 + 2\bar{F}dudv + \bar{G}dv^2 = 0$, the asymptotic lines $\psi_2 \equiv Ldu^2 + 2Mdudv + Ndv^2 = 0$, the lines of curvature given by $J(\psi_1, \psi_2) = 0$, the curves given by $J(\psi_1, J(\psi_1, \psi_2)) = 0$, and the characteristic curves given by $J(\psi_2, J(\psi_1, \psi_2)) = 0$, where \bar{E} , \bar{F} , \bar{G} are fundamental magnitudes of the first order. He⁵⁵ has also given a proof of

Strazzari's⁵⁶ formula $\frac{dS}{d\sigma} \cos \theta = \rho_1 \rho_2$ and has pointed out that when the con-

gruence is normal, this becomes $\rho_1 \rho_2 = \frac{dS}{d\sigma}$ which corresponds to the well

known theorem⁵⁷ of Gauss, and has mentioned several other similarities between the two theories.

Normal congruences. A congruence of straight lines is said to be normal if its rays can be cut at right angles by a surface, and therefore in general by a family of surfaces. Normal congruences were the first to be studied particularly in connection with the effect of reflection and refraction upon rays of light. Malus⁵⁸ and Dupin showed that if a system of rays constituting

a normal congruence is subjected to any number of reflections and refractions at the surfaces of successive homogeneous media, the congruence remains normal throughout. Beltrami⁵⁹ proved that 'if a surface of reference of a normal congruence be deformed in such a way that the directions of the lines of the congruence with respect to the surface be unaltered, the congruence continues to be normal'. This theorem has been proved in different ways by Rowe⁶⁰ and Darboux⁶¹. Ribaucour⁶² showed that if tangent planes be drawn through the rays of a rectilinear normal congruence to any surface, the congruence remains normal if the surface be deformed in any manner carrying the rays in its tangent planes.

The necessary and sufficient condition that the congruence be normal is $f' = f$ or $E\delta'' + G\delta - 2F\delta' = 0$. Other forms of the condition have been given by Slotnik⁶³ and Foster⁶⁴.

When the congruence is normal, the focal points coincide with the limit points; the principal surfaces and the developable surfaces become the same, the focal planes are at right angles, the characteristic ruled surfaces through a line coincide with the ruled surfaces whose spherical representations are minimal lines. The author has established the following new theorem⁶⁵ on Normal Rectilinear Congruences both analytically and geometrically:—

'There exist ∞^2 ruled surfaces of an ordinary congruence the osculating quadrics of which are equilateral, but there are only ∞^1 such ruled surfaces if the congruence is normal'. He has also shown that spherical representations of the distributive ruled surfaces through a line of a normal rectilinear congruence are isometric⁶⁶. The curves on the sphere representing the principal ruled surfaces through a line of a normal rectilinear congruence are also isometric⁶⁷.

Pitch of a pencil of the congruence at a ray. If we take a closed curve C and through points of it draw lines, then the surface generated by these lines is a ruled surface. Let the equations of the ruled surface be $\xi = x + uX$, $\eta = y + uY$, $\zeta = z + uZ$, where (x, y, z) are the co-ordinates of a point O of the curve C and are functions of v where v is the arc of C measured from some fixed point on it up to O, u is the distance along the generator, measured from O and X, Y, Z are the direction cosines of the generator.

The equation of the orthogonal trajectories of the generators is $u = \text{const.}$ — $\int (Xdx + Ydy + Zdz)$. This integral invariant has been considered by Cartan⁶⁸. The orthogonal trajectories are closed curves if $\int (Xdx + Ydy + Zdz) = 0$ where the line integral is taken over the boundary of the closed curve C. The distance between the two points where an orthogonal trajectory cuts the generators through O is $\int_c (Xdx + Ydy + Zdz)$. The author⁶⁹ has called this distance 'the pitch (p) of the pencil' and has developed a theory of the pitch obtaining various properties and generalizations of known theorems. The pitch is the same for any orthogonal trajectory.

Consider a thin pencil formed by rays adjacent to a ray l of the congruence given by $\xi = x + tX$, $\eta = y + tY$, $\zeta = z + tZ$, where x, y, z ; X, Y, Z are functions of two parameters u and v . We have $p = \int_c (Xdx + Ydy + Zdz) = \int_c \sum X_1 x_1 du + \sum X_2 x_2 dv$, where c is the closed curve on the surface of reference which forms the boundary of the area dS on it cut off by the pencil, which by Green's formula gives

$$p = \iint_{dS} (\sum X_1 x_2 - \sum X_2 x_1) dudv, \text{ or } \frac{dp}{d\sigma} = \frac{f-f'}{\sqrt{EG-F^2}} \text{ or } \frac{dp}{d\sigma} = 2\rho \cdot \cot \theta,$$

where 2ρ is the distance between the focal points, and θ is the angle between the focal planes,

Hence the value of $\frac{dp}{d\sigma}$ depends only upon the line l and is the same

for all the pencils of the congruence containing l and is equal to the mean parameter of the congruence. Its vanishing is the condition that the congruence be normal. This result also follows from Bianchi's formula⁷⁰ $h = \sqrt{d^2 - \lambda^2}$, where d and λ are distances between limit points and focal points respectively and h is the mean parameter of the congruence.

When the ruled surface is deformed, the generators remaining straight, the pitch of the pencil remains unaltered.

From $p = \iint_{dS} (\Sigma X_1 x_2 - \Sigma X_2 x_1) du dv$, it follows that the pitch of the pencil is always zero, if $\Sigma X_1 x_2 - \Sigma X_2 x_1 = 0$, i.e., if the congruence is normal. This condition has been shown to be also necessary.

If the rays of a congruence be the tangents to a family of ∞^1 curves on a sheet of the focal surface and if these curves be taken as the parametric curves $v = \text{const.}$ and their orthogonal trajectories be taken as the parametric

curves $u = \text{const.}$, we get $\frac{dp}{dS} = \frac{1}{\rho_{gu}}$, the geodesic curvature of the curve $v = \text{const.}$

If the family of curves on a sheet of the focal surface be a family of geodesics then $\frac{1}{\rho_{gu}} = 0$, $\therefore p = 0$, i.e., the congruence is normal, which agrees

with the well-known result, viz., "A necessary and sufficient condition that the tangents to a family of curves form a normal congruence is that the curves be geodesics".

Considering the special congruence formed by the lines that meet two curves C_1 and C_2 which are such that along C_1 , u is constant and along C_2 , v is constant, the author has shown by different methods that the pitch of any pencil of the congruence at the ray PQ where P is a point on C_1 and Q

is a point on C_2 is $-\iint \frac{\delta^2 r}{\delta u \delta v} du dv$, where r is the distance PQ. He has further given a generalization of this result for any congruence.

Other expressions for the pitch of a pencil of the congruence at a ray. Delglieze⁷¹ has shown that through a line l of the congruence two ruled surfaces pass which have the same central point, and that the sum of their parameters of distribution is equal to the mean parameter of the congruence. The author⁷² has given a simpler independent proof of Delglieze's result, and has deduced that the pitch of a pencil of the congruence at l is such that

the value of $\frac{dp}{d\sigma}$ at l is equal to the sum of the parameters of distribution of the two ruled surfaces through l which have the same central point.

Also if the sum of the parameters of distribution of the two ruled surfaces through l which have the same central point is zero, the congruence is normal and the pitch vanishes.

Delglieze has also shown that through any line l of the congruence two ruled surfaces (non-developable) pass whose lines of striction lie on the focal

sheets and that the parameter of distribution of each of these two surfaces is equal to the mean parameter of the congruence.

From this result it can be deduced that the value of $\frac{dp}{d\sigma}$ at the ray l is equal to the parameter of distribution of each of the two ruled surfaces through l whose lines of striction lie on the focal sheets. Also, if the parameter of distribution of any one of the two ruled surfaces through l whose lines of striction lie on the focal sheets vanishes then the congruence is normal and the pitch is zero.

The author has established that the two ruled surfaces through l which have their parameters of distribution equal to semi-mean parameter of the congruence have the same central point, and that the value of $\frac{dp}{d\sigma}$ at l is equal to twice the parameter of distribution of any one of the two ruled surfaces through l whose parameters of distribution are equal and whose central points coincide.

Srinivasiengar⁷³ has shown that if the central plane for one of the mean surfaces makes an angle ϕ with the central plane for one of the two surfaces through a given ray which have their central point on the ray at a given point, it makes the angle $\frac{\pi}{2} - \phi$ with the central plane for the other. If we

take two points A and B equidistant from the middle point of a ray on either side, the parameters of distribution for the pair of surfaces which have their central point at A are equal to those for the surfaces which have their central point at B. He has also shown that the distance of a focal point from the middle point is numerically equal to $\sqrt{-\beta_1\beta_2}$, where β_1 and β_2 are the parameters of distribution for the mean surfaces, and has generalised this result in two ways.

The author has established a relation between the pitch of a pencil of a congruence at a ray and Levi Civita's Anormalita⁷⁴ of a rectilinear congruence and has shown that the vanishing of the Anormalita is the condition that the congruence be normal⁷⁵. He has obtained the following generalizations⁷⁶ of the well known theorems of Malus-Dupin, Beltrami and Ribaucour :—

The pitch of a pencil at a ray of the congruence formed by the incident rays remains unaltered by reflection, and also by refraction except for a factor which is equal to the ratio of the refracting indices of the two media.

If the surface of reference be deformed and with it the congruence as in Beltrami's theorem or in Ribaucour's theorem, the pitch of any pencil of the congruence remains unaltered by deformation.

Other special congruences. Besides normal congruences there are other special congruences which offer points of interest, viz., Isotropic congruences, congruences of Weingarten, Waelsch, Guichard, Bianchi, Ribaucour, Appell, Rozet, congruences which correspond asymptotically, hyperbolic and parabolic congruences, reciprocal congruences, and stratifiable congruences. We shall describe important work recently done on some of them.

Isotropic congruences. An isotropic congruence is one whose focal surfaces are developables with minimal edges of regression and hence the developables are represented on the sphere by minimal lines. Ribaucour has

obtained several properties of such congruences. Kommerell⁷⁷ has given expressions for the coordinates of a point on the middle surface of an isotropic congruence which enable an isotropic congruence to be constructed easily. Vincensini⁷⁸ has given a geometrical construction by means of which he deduces new families of associated minimal surfaces of isothermal spherical systems and new isotropic rectilinear congruences from every system of associated minimal surfaces. He has deduced an Appell's congruence from every isothermal spherical system and an isotropic congruence from every Appell's congruence.

Weingarten congruences. A Weingarten congruence is one for which the asymptotic lines of both the focal surfaces correspond to one another. For

such congruences $K_1 K_2 = \frac{1}{d^2}$, where K_1 and K_2 are the total curvatures of

the two focal surfaces and d is the distance between the limit points.

Hans Jonas⁷⁹ has obtained several theorems on Weingarten congruences. Fubini⁸⁰ has proved these theorems by purely projective methods and has also obtained several other results on the theory of Weingarten congruences. Defining a pencil of congruences as a set of ∞^1 congruences which are such that they have a common first focal surface, the corresponding points of the second focal surface generate a line, and the tangent planes to the second focal surface belong to a pencil, he has proved that if one congruence of a pencil is a Weingarten congruence, all the congruences of the pencil are Weingarten congruences and that two Weingarten congruences always determine a pencil of congruences. Finikoff⁸¹ has studied Rozet's congruences and has proved that a Rozet's congruence is Weingarten if and only if it belongs to a linear complex.

Congruences of Waelsch. A congruence of Waelsch is characterised by the property that the asymptotic lines of one of the focal surfaces are conjugates of the asymptotic lines of the other focal surface and conversely. Here

$K_1 K_2 = -\frac{1}{d^2}$. Badaljan⁸² has obtained geometrical characteristics of con-

gruences which have constant Waelsch invariant. He has shown that a necessary and sufficient condition that a rectilinear congruence with focal surfaces (M_1) , (M_2) have constant Waelsch invariant is that there exist two straight lines $M_1 M_1$, $M_2 M_2$ associated with each element $M_1 M_2$ which are reciprocal polars with regard to the Darboux quadrics adjoint to the homologous points of (M_1) , (M_2) .

Congruences of Guichard. Congruences whose focal surfaces are met by the developables in the lines of curvature are called congruences of Guichard. Such congruences are represented on the sphere by curves representing also the asymptotic lines of a pseudospherical surface. Guichard showed that a necessary and sufficient condition that the tangents to the lines of curvature in one family of a surface form a congruence of Guichard is that one sheet of the evolute of the surface be a surface of Voss (i.e., a surface with a conjugate system of geodesics) and that the tangents constituting the congruence be those which are parallel to the normals to the latter. He also showed that the middle envelope of a congruence of Guichard is a surface of Voss.

Pylarinos⁸³ has obtained properties of Guichard's congruences without employing the general theory of line congruences.

Congruences which correspond asymptotically. Two congruences are said to correspond asymptotically if their lines correspond in such a manner that the two families of developables of each correspond to the two families of developables of the other. Takeda⁸⁴ has developed the theory of such congruences basing it on a completely integrable system of differential equations satisfied by the Plücker coordinates of the lines of the congruence. He has found a relationship between an asymptotic correspondence and a projective deformation of pairs of congruences studied by Finikoff⁸⁵. Quadratic complexes having contact of various orders with the given congruence are derived. He has also defined a certain pair of cubic complexes associated with a general line of the congruence and has discussed the congruences when particular conditions are imposed on these complexes.

Hyperbolic and parabolic congruences. The lines common to two linear complexes are said to form a linear congruence. A linear congruence is hyperbolic or parabolic according as it has two transversals or one. Srinivasiengar⁸⁶ has dealt with hyperbolic and parabolic linear congruences. He has set up a correspondence between the lines of a hyperbolic congruence and the points of a quadric in ordinary space. To a curve on the quadric there corresponds a ruled surface of the congruence. He has translated certain properties of curves on a quadric into theorems on the ruled surfaces of a linear congruence. He has shown that rays of a hyperbolic linear congruence for which the mean parameter of distribution is equal to a given constant lie on one or the other of two quartic scrolls having the directrices as double lines. The axes of the linear complexes of the asymptotic curves of any scroll of the hyperbolic congruence are all parallel to the middle plane, and their locus is a cylindroid. Of all scrolls belonging to a hyperbolic congruence, there are two families for which the Gaussian Curvature at a given point P is a maximum or minimum. The asymptotic curve through P of a scroll of one family meets the ray again at a point Q such that the tangent plane at P to one of the scrolls of one family is also the tangent plane at Q to one of the other family. The two families having maximum or minimum Gaussian Curvature at Q are identical with the two families of scrolls at P . He has also given a mode of generation of a parabolic linear congruence.

Reciprocal congruences. Grove⁸⁷ has studied reciprocal congruences and has expressed the condition for a ruled surface as the vanishing of an invariant. Mac Queen⁸⁸ has discussed the osculating quadrics of ruled surfaces in such congruences.

Stratifiable congruences. A pair of rectilinear congruences L_1 and L_2 of lines l_1 and l_2 are said to be stratifiable if ∞^1 surfaces Σ_1 and also Σ_2 can be constructed such that the tangent planes to Σ_1 's at points of l_1 all pass through l_2 and similarly for the tangent planes to the Σ_2 's. With such a pair $L_1 L_2$ there is associated the congruence L_3 of lines l_3 , which is the common perpendicular to l_1 and l_2 . Bachvaloff⁸⁹ has shown that, if L_3 is a given arbitrary pseudospherical congruence, L_1 and L_2 will always exist. If further l_3 cuts l_1 and l_2 in N_1 and N_2 so that the midpoint of $N_1 N_2$ is also the midpoint of the focal points of l_3 , then $N_1 N_2$ is of constant length and the angle between l_1 and l_2 is constant. If the length of $N_1 N_2$ is chosen arbitrarily there will be two pairs of stratifiable congruences (L_1', L_2') and (L_1'', L_2'') such that l_1' is perpendicular to l_2'' and so is l_2' to l_1'' . If $N_1 N_2$ coincide with the limit points of l_3 , these two pairs will coincide. He has

also proved that if we are given a pair of stratifiable rectilinear congruences L_1 and L_2 with associated families of surfaces Σ_1 and Σ_2 , and if L_3 be the congruence of common perpendiculars to corresponding elements l_1 and l_2 and if N_1 and N_2 be the points of intersection of l_3 with l_1 and l_2 , and if the surfaces generated by N_1 and N_2 belong to Σ_1 and Σ_2 respectively, then the congruence L_3 is necessarily a pseudeospherical congruence.

Finikoff⁹⁰ has further elucidated and extended the results of Bachvaloff.

Rossinski⁹¹ has dealt with the existence of pairs of stratifiable congruences of various types, for example, congruences such that the lines of one are the intersections of the focal planes of the other.

Deformation of Congruences. Rossinski⁹² has worked on the deformation of rectilinear congruences preserving certain special systems of ruled surfaces. He has shown that if the lines of congruence C lie in the corresponding tangent planes of the surface of reference, the middle surface of C is preserved. When the lines of C are orthogonal to these planes, the surface of reference may be any Monge surface, the mean ruled surfaces corresponding to its lines of curvature. He has also considered the problem: for what surfaces S and what corresponding congruences C attached to S does there exist a conjugate family of isoclinic or orthogonal surfaces of this congruence which retain this property either under a general deformation or under one preserving a conjugate net of lines on S ? Tikhotzky⁹³ has applied Fubini's and Cartan's definition of applicability to the rectilinear congruences of the Euclidean space. He has given a definition of the applicability of congruences which is analogous to the definition of geometrical applicability (conformal correspondence in the theory of surfaces) and has shown that it is possible to find a pair of congruences which are applicable and which depend on an arbitrary function of two variables. Finikoff⁹⁴ has considered the simultaneous deformation of two congruences. He has shown that two congruences which are such that the lines joining the corresponding foci of the lines of the congruence are tangent to the two focal surfaces, preserve that property after a simultaneous deformation, and has discussed several particular cases of deformations of this type.

Application of tensor analysis to the study of ruled surfaces and rectilinear Congruences. Duschek-Mayer⁹⁵, Hlavaty⁹⁶, Craig⁹⁷ and others have presented the classical material of the differential geometry of curves and surfaces with the use of tensor methods and have dealt with ruled and other special surfaces. Hlavaty has obtained a trivalent symmetrical tensor which stands godfather to ruled surfaces. Williams⁹⁸ has applied tensor methods to investigate ruled surfaces in Euclidean space of four dimensions and has obtained certain interesting results. He has shown that the Gaussian curvature of the surface is never positive. Defining a developable surface as a ruled surface with zero Gaussian curvature, he has shown that a ruled surface which is developable is the tangent surface of a twisted curve and conversely. There are no ruled surfaces with constant (non-zero) Gaussian curvature. The only minimal ruled surfaces in R_4 are those in R_3 . He has considered the problem of deforming a ruled surface in R_4 into another surface and has obtained a particular solution.

Slotnik⁹⁹, Dubnow¹⁰⁰, Ritter¹⁰¹, Sprague¹⁰², and others have applied tensor methods to the study of rectilinear congruences.

By means of Study's dual coordinates¹⁰³, a line A is determined by its direction cosines $\alpha : (\alpha^1, \alpha^2, \alpha^3)$ and by the vector $\bar{\alpha} : (\bar{\alpha}^1, \bar{\alpha}^2, \bar{\alpha}^3)$ representing the moment of a unit vector along A about the origin of coordinates, so that

the fundamental relations are $(a.a)=1$ and $(a.\bar{a})=0$, where $(a.b)$ denotes the scalar product of the two vectors a and b .

The coordinates of A are written as the dual vector $A=a+\varepsilon\bar{a}$, where $\varepsilon^2=0$. Thus $(A.A)=(a.a)+2\varepsilon(a.\bar{a})=1$, so that the point with the dual coordinates A lies on the unit sphere : $(A.A)=1$.

The point x lies on the line A if and only if $x \times a = \bar{a}$, where $x \times a$ denotes the vector product of the vectors x and a . If c is a third vector, $(ab.c) = (abc)$, the right hand side being equal to the determinant of the three vectors. Let $m : (m^1, m^2, m^3)$ be the coordinates of the middle point of the line A of a congruence. The coordinates of the line are then $A=a+\varepsilon(m \times a)$, where a and m are functions of two independent parameters u^1, u^2 . The derivative of this equation with respect to u^1 is written, as

$$A_1 = a_1 + \varepsilon(m_1 \times a + m \times a_1).$$

Consider the dual tensor $G_{ik} = (A_i.A_k)$. If this is written in the form $G_{ik} = g_{ik} + \varepsilon \bar{g}_{ik}$, we have

$$g_{ik} = (a_i.a_k) \text{ and } \bar{g}_{ik} = (m_i a a_k) + (m_k a a_i).$$

If m_1 be expressed as a linear combination of the vectors $a, \frac{\delta a}{\delta u^1}, \frac{\delta a}{\delta u^2}$, i.e.,

$$m_1 = p_1 a + q_1^i a_i, \text{ we get } \bar{g}_{ik} = q_1^i e_{k1} + q_1^k e_{i1}, \text{ where } e_{ij} = (a_i a_j a).$$

The coordinates of the focal points of A are of the form $m \pm ra$. Hence $(m \pm ra)_i (m \pm ra)_k a = 0$ which becomes $q_1^i q_1^k e_{is} \pm r(q_1^i e_{ik} + q_1^k e_{is}) + r^2 e_{ik} = 0$ and gives the two equations $q_1^i e_{ik} + q_1^k e_{is} = 0$ and $r^2 = \frac{1}{2} q_1^i q_1^k e_{is} e^{ik}$, where e^{ij} is the tensor conjugate to e_{ij} . \therefore we get $\bar{g}_{ik} = 2q_1^i e_{k1}$ or $q_1^i = \frac{1}{2} \bar{g}_{ik} e^{k1}$. Also if q_{ik} is the tensor associate to q_1^i by means of the fundamental tensor, we have $q_{ik} = q_1^s g_{ks}$. Slotnik has shown that the necessary and sufficient condition for a congruence to be normal is $e^{ik} q_{ik} = 0$. He has proved that if a congruence is such that the tensor G_{ik} can be made to assume the Techebycheff form, i.e., $G_{ik} = 1$, then its developables meet the focal surfaces in their lines of curvature i.e., the congruence is a Guichard congruence. If a congruence is such that for it r and $e^{ik} q_{ik}$ are constant, then the focal surfaces of the congruence have constant Gaussian curvature i.e., the congruence is a congruence of Bianchi. He has also dealt with the problem of Schur viz., to find when the focal surfaces of a congruence are isometrically mapped upon one another, corresponding points being those joined by the lines of the congruence.

In the above tensor notation the equations of three important families of ruled surfaces through a ray of a rectilinear congruence, namely, the developable surfaces, the principal surfaces and mean ruled surfaces come out in the following elegant forms $\bar{g}_{ik} du^i du^k = 0$, $S_{ik} du^i du^k = 0$, (where $S_{ik} \equiv Q_1^s g_{sk}$) and $q_{ik} du^i du^k = 0$ respectively.

Various well-known properties of these families of surfaces and of some special congruences like the isotropic congruence can be deduced immediately.

Sprague has obtained in tensor form involving the fundamental tensors of the focal surfaces of the Weingarten congruence the conditions that a given conjugate net on a surface be such that tangents to both families of curves of the net form Weingarten congruences,

The powerful method of tensors can be fruitfully employed to find other properties of rectilinear congruences and to investigate ruled and other special surfaces in Euclidean and other spaces of four and higher dimensions. It opens a new line of approach which may be helpful toward a further development of this fascinating subject.

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SECTION OF STATISTICS

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STATISTICS GETS FIRMLY WOVEN INTO OUR FABRIC OF THINKING

(*Delivered on 4 January, 1946*)

With a full heart I thank the Indian Science Congress Association for electing me President of the Statistics section of the Congress this year. The responsibility I am undertaking is greater, perhaps significantly greater, than the average because this is the first occasion when the Statistics section is able to function independently. However, being honoured in my own home town, I run no risk of being mistaken as the proverbial prophet. It may not generally be known that the earliest person to give stimulus to statistical research and training in India was Dr. (subsequently Sir) Brajendra Nath Seal who, about a quarter of a century ago, instituted the first chair of Mathematical Economics and Statistics in India in Mysore University, under whose very hospitality we are now meeting. He was also responsible, in no small measure, for promoting the growth of the Indian Statistical Institute at Calcutta. I offer to his memory the homage of us all.

STATISTICS COMES OF AGE

During the 33 years the Indian Science Congress has been meeting statistical science has, in this country, as elsewhere, passed through several phases of scientific and pseudo-scientific activity, of ridicule and neglect and of acceptance and enthronement. However, it may now safely be claimed that, through sheer power of logic, the statistical method has secured a place for itself in all fields of thought, business and administration. Quite half a century ago, Florence Nightingale writing to Sir Francis Galton had made an eloquent plea for "some teaching how to use statistics in order to legislate for and to administer our national problems with more precision and experience", and regretted that "though the great majority of cabinet ministers, of the Army, of the Executive of both Houses of Parliament had received a University education, that University education taught them little of the practical application of statistics". (quotation from *Jour. Amer. Stat. Assn.* Vol.40 (229) p. 6). The inclusion in 1944 in the Home University series of a book on statistics by L.H.C. Tippet is a sure indication of the revolution of thought that necessity has brought about in this interval, namely, that apart from the statutorily established university, the home university should ensure that stochastic method is firmly woven into the very fabric of our thinking, as well as say, accounting now is woven into our mode of thinking.

STATISTICS AS A UNIFYING ELEMENT IN ALL SCIENCE

When regarded with sufficient generality, statistics is a unifying element in all science. In the pure theory of statistics, very intricate problems of

testing hypothesis have been probed into, and the latest researches in finite geometries and galois fields have been impressed into the question of designing of statistical patterns, and in general into the whittling away of the area of the unknown. Mathematical expressions have also been worked out to express the randomness of a sample, and to measure the distance that may be presumed to separate two distributions if they are not randomly drawn from the same universe. The probability approach dominates the entire range of theoretical physics. The statistical method also pervades a wide range of physico-chemical phenomena. Recent advances in genetics, medical research and bioassays have been made by the methods of statistics and mathematical representation. Social sciences in their bid for inclusion in the family of exact sciences have sought extensive help of statistical methods. Based on statistical foundations, life assurance has been both a social service and a commercial success. Methods appropriate for the treatment of meteorological observations have value in agriculture and anthropometry, biology and ecology, industrial production and industrial relations. Some have gone further afield, such as, archaeological and ethnic problems in the Near East, and frequency distributions of the length of sentences to characterize aspects of the styles of authors. Statistical ideas are at the root of many current theories and practices in political economy and social reform. Like operational research in relation to fighting services, statistics have delivered to workers in a diversity of scientific fields an approach to problems and certain techniques for the measurement of essential factors simultaneously from a number of different angles. Neglecting resistance through pure temperament and incompatibility, it may also be claimed that statisticians have helped to bring about contacts and a synthesis amongst specialists who work too much in isolation and almost without interaction.

STATISTICS IN INDUSTRY AND BUSINESS

Commercial bodies and industrial organizations are also interested in statistics. Their field is naturally their own market, and factory, and so they confined themselves to prices and wages, labour and conditions of work, banking facilities and profits and taxes, extending, however, latterly to problems like demand by consumers, effective substitution and setting up standards and securing quality control in production. Owing to the impetus given to this last aspect—namely, quality control, during the war, and the interest recently taken in the matter by the Council of Scientific and Industrial Research, there is a growing use by industrialists and engineers of the methods and researches initiated by statisticians in these fields. It must however be admitted that the routine use of such methods is in India still in its infancy. This is probably due to two or three causes. The first is due to ignorance or inertia to catch up on the latest developments, and the belief of businessmen that as they have got on well enough in the past without any such adventitious aids they can continue to plod on to no great disadvantage to themselves, particularly when the buyer is also ignorant and is prepared to accept in good faith anything that is placed on the market by a well known firm. Fortunately the persistence in such self deception is neither extensive nor real, and producers are now often anxious to employ the fruits of research of others. A second obstacle to the rapid or successful penetration of statistical methods in industry is technical. It is pointed out that there is lack of complete equivalence between industrial reality and the mathematician's models thereof, and the many technical complexities of manufacture and research make it advisable that the statistician's results may only be taken as tentative by the industrialists. Only those who are thoroughly familiar with the industrial or experimental processes at hand can obtain

the full benefits of statistical methods, but they generally have no time or means to obtain statistical qualifications themselves. The only practical remedy is continuous and close co-operation amongst the technicians themselves. Perhaps as a third obstacle we may recognise that the literature on the subject is written largely by statisticians for statisticians, and the mode of thought and terminology are largely unfamiliar to the uninitiated, and the practical man might well exclaim in Sheridan's words "Egad, I think the interpreter is the harder to be understood of the two".

WANTED—MORE, NOT LESS, MATHEMATICS

An excellent example of such interaction occurs where the analytical statistician shows flexible response to changing social and economic needs, and where in turn the economist is transformed from a social philosopher to an engineer. The statistician must fully realise that however indispensable mathematics is, it is not sufficient, for instance, when analysing the behaviour of prices, merely to be familiar with time series analysis and correlation methods, but in addition, he should know a great deal about the particular commodity of service concerned. The economist on the other hand must not be satisfied with drawing graphs and diagrams more befitting Sunday periodicals, nor should he deal too much with the mechanical application of statistical methods which are essentially designed for use with data whose necessary characteristics are homogeneity, independence of observation, randomness of selection, and normal, or nearly normal, distribution. Most economic data do not meet these conditions and they therefore call for more specialised methods of statistical treatment. Yule's classic example (*Jour. Roy. Stat. Soc.* 89(1) 1926 p. 1.), of the high correlation between standardised mortality rates and proportion of Church of England marriages to total marriages, shows how a purely chance correlation between two trends can appear without any causal relation between them. Several methods have of course been suggested to render economic time series more amenable to statistical analysis though it is doubtful whether a fool-proof universal method can ever be devised. The variate difference method as proposed by "Student" and O. Anderson (G. Tintner, "The variate difference method", Bloomington, 1940) is essentially based on the assumption that the systematic or non-random part of the time series is such that it can be wholly or partly eliminated by finite differencing. But by restricting the range to short length an artificial independence is created and some part of the available information is lost, and the method is not efficient *a la* Fisher. Wold's treatment ("A study in the analysis of stationary time series", Uppsala, 1938) involving harmonic analysis is also practical and statistical as distinguished from the probability aspect, and the mathematical difficulties involved are great. Recently, the Division of Statistical and Historical Research (*Jour. Amer. Stat. Assn.* 34 (205), 1939 p. 377,) has begun to test the variables used in correlation analysis for homogeneity by the standard methods of analysis of variance. Thus the variance of the standard deviations of group means and group standard deviations vary more than would be expected by random sampling from a homogeneous population. The most recent contribution to such studies is by L. R. Hafstad (*Jour. Amer. Stat. Assn.*, 35(210), 1940 p. 347-61), which, using a method known as Bartel's technique originally used in astronomy, enables the statistician to determine also how many items are required to eliminate the influence of serial correlation on the standard deviation of the means of samples. This brief reference to some modern methods of analysis is intended to show the need for not less, but more, mathematics in economic statistics. The analysis of price behaviour, and of price determining forces, is of far reaching consequence in production and price programmes,

both to industrialists and to the State when the shift is from market to administered prices. Planning is a live issue, and important decisions have to be taken in regard to the features of modern economic society which will have great potentialities for good or for evil according to our factual knowledge and scientific skill of handling such factual knowledge, and both these are within the competence of statistics.

STATISTICS AND ADMINISTRATION

(i) Governments are, of course, the largest creators, preservers and even destroyers of statistical information. National disasters, wars, famines, pestilences, and, now reconstruction planning, have driven them to statistics and statisticians, however produced and wherever found. It is the same sequence everywhere, in Washington, in Whitehall and in New Delhi, only there is a time lag. In war and emergency the need is for more effective mobilization of resources. In peace, the need arises because of the formulation of policies, all of which, however, have the common objective of freedom from want, and of social service and security through the State. These no doubt created a change of heart in Governments and amongst their usual advisers, in that they exhibited increasing faith in the collection of statistical facts, and paid large attention to the statistician. But in this effort there was a lack of all the three essential requirements of statistics—sufficiency, efficiency and consistency. There was little data, few workers of competence, and the least number of contacts and agreements amongst the workers themselves. During the war years, and during the periods of shortage of food, clothing, shelter and transportation facilities, new and quick methods had to be devised for obtaining facts and adopting policies suggested by facts, and no doubt momentous and fateful decisions were made with, without, and in defiance of statistical support.

(ii) The neglect to take out a quinquennial census of population in 1935, long pressed on the Government in Great Britain, caught that Government napping when in 1939 at the outbreak of war the National Register had to be hurriedly prepared. In like manner, the ordering of a limited tabulation of the Indian census of 1941 found the Government of India without the basic data to know what numbers to plan for, where situated, of what ages and maintaining with what means of livelihood. Out of want and necessity sometimes cometh great good, and this shortsightedness on the part of Government was in a way rectified by the fortunate preservation by the Census Commissioner of enumeration slips designed to belong to every fiftieth person. This sample, come to be known as the Y-sample, was also left in cold storage until another civilian officer influenced the Government to cause an investigation on this sample. It is now known, as will be shown presently, that the agreement between the Y-sample and the complete count is in many cases quite satisfactory, and that satisfactory age tables, life tables, and projections can be obtained on the basis of the Y-sample.

(iii) The statistical work of the Indian Statistical Institute and the Imperial Council of Agricultural Research extending over many years have also given great confidence in the suitability of the method of investigation by sample. A large number of schemes for ascertaining the several facets of economic life of the country—cost of living, employment, volume of postal transactions, traffic density etc.—by the sample method, are being operated. It is to be hoped that Government is not only counting on the gain in time and cost but is convinced of the effectiveness of the sample giving possibly more reliable results than the so-called complete inventory method itself, and at any rate, of its adaptability to give, for a unit expendi-

ture of labour, results within a stipulated degree of uncertainty. This latter point has to be emphasised for there remains a great good deal by way of preliminary exploration before proper stratification and proper sampling procedure can be hit upon.

(iv) Another weak point is the temperament of the people which, combined with their ignorance or suspicion, renders the collection of ready, correct and complete information difficult or impossible. Governments are therefore obliged to base their counting system on a much more systematic and continuous manner than they have yet done. The carrying out of the census on a phoenix system at ten-yearly intervals, the conduct of "special" inquiries for each isolated problem without proper relation to associated inquiries, and the failure to gather the bye-products of an enquiry (often more valuable than the main "special" enquiry itself) are some of the weak points of statistical organization in the country.

(v) A number of our Governments are now setting up statistical bureaux as permanent organizations. How far they will reproduce the models of the Statistical Bureaux of the Census, and Budget, and Agriculture in the United States of America, or even on the pattern suggested for the United Kingdom by the Royal Statistical Society, will depend on the scope and personnel of the Bureaux themselves, but one of their first duties must be to maintain a proper record of house numbers, and to discover a Master-sample which could be adapted to every conceivable necessity. Insufficient or inefficient handling of statistics often leads Governments to risk of errors of the second kind, viz. acceptance of wrong hypothesis, particularly because they are obliged to take, on what evidence they can get, non-postponable decisions in an unambiguous yes-or-no form. These Bureaux and their sponsors, their respective Governments, should realise that statistical organization and research are essentially of the co-operative or team-work nature. As many technicians, field workers, and volunteers who could assist and give counsel as possible should be associated with their work, and the widest possible facilities for experiment, consultation and discussion should be made possible. It is not proposed to describe here the functions and organization of Government statistical bureaux as excellent accounts have recently appeared in the journals of the Royal Statistical Society and the American Statistical Association but it is sufficient to insist that the authorities should genuinely recognise the use and value of statistics in their art of good government. When a high ranking member of Government who was unable to lay his hand on his ticket in spite of incessant searching was reassured by the inspector who desired to see it "It is all right, sir ; we know *you* will not risk travelling without buying a ticket," the former promptly exclaimed, "But how the devil do I know where I am going, by what route and in what class and what is the proper fare". Statistics is like this railway ticket—no planning is possible or sensible without first planning for facts.

ANALYTICAL WORK ON ADMINISTRATIVE STATISTICS

I may here illustrate the scope for analytical work on administrative statistics only by some recent work on population data, on the economics and statistics of road development in India and kindred problems, on which I was actively engaged during the last 18 months. But, some of my earlier work on trade unionism, labour disputes, absenteeism and migration of labour (published in the *Indian Journal of Economics* and elsewhere during 1925-27) as well as work on the life-line of the thyroid gland, and on the assessment of nutritional status by arm, chest and hip width indices (published in the *Indian Journal of Medical Research* during 1930-34), and

on the infectivity of mosquitos and on the analysis of parturition data (published in *Sankhyā*, Vol. 1) indicate the scope of similar analytical work in other fields.

(I) DEMOGRAPHIC STUDIES

Demographic studies in western countries have interested themselves in the problem of making estimates of the size and distribution of population at future dates — estimates based on several reasonable assumptions about the changes in vital ratios and migration. The outstanding estimates of that nature are those contained in "The future population of Europe and the Soviet Union — 1940-1970" by F.W. Notestein and others, and in the White Paper on Population, and those given by the Statistical Sub-committee to the Royal Commission on population, the latter two with special reference to England and Wales. The authors of the Bombay plan for the economic development have assumed that the population of India will, by 1962, have reached 494 millions. But it has first to be proved that we have the data of sex and age distribution and knowledge of reproductive and mortality rates in different parts of the country and at different dates to make possible a strictly scientific estimate.

(i) Population Projections by Empirical Formulae :

In 1939, computations were done in the Statistics Department of the Mysore University to obtain population estimates for 1941 in India as a whole and for 21 administrative divisions including Provinces and Indian States individually. These results were published in *Sankhyā* Vol.5, page 281 in 1940. An examination of these estimates with the enumeration at the 1941 Census (now available) shows that the methods give reasonably good results for 80 per cent of the population of the country. Briefly the results are given in the Statement below:—

	population in millions			difference between enumerated and estimated as percent- age of enumerated			
	enumerated in 1941	estimates by functions			I	II	III
		I	II	III			
Indian States	94.48	91.4	93.76	92.34	3.26	0.76	2.27
British territory	294.52	272.8	283.67	282.09	6.70	3.68	4.22
Whole of India	389.00	364.2	377.43	374.43	6.38	2.97	3.75

All differences are positive, that is, enumerated numbers exceed the corresponding estimated numbers. By the estimating function III, the difference between estimate and enumeration was

less than 1% in

Hyderabad (16.34 millions); Madras (52.16 millions); Mysore (7.33 millions); Bihar and Chottanagpur (36.34 millions)—4 areas with 112.17 million persons;

between 1% and 5% in

U. P. (55.02 millions); Jammu and Kashmir (4.02 millions); Indian States other than those named here individually (66.74 millions); Orissa (5.70 millions); Bombay (20.85 millions); Punjab and Delhi (29.34 millions)—6 areas with 181.72 million persons;

between 5% and 10% in

Sind (4.54 millions) ; C. P. and Berar (17.02 millions) ; and Assam (10.20 millions)—3 areas with 31.76 million persons ; and

exceeded 10% in

N.W.F.P. (3.04 millions) and Bengal (60.31 millions)—2 areas with 63.35 million persons.

These results enable us to expect that for about 80 per cent of the country it is possible to derive estimates within 5 per cent difference.

(ii) *Life Table Methods of Comparison :*

The above methods however supply only totals. But they cannot give the distribution of the population among different age groups for which other methods have to be explored, namely, those by the use of actuarial life tables.

Starting with the distributions by sex and age of the population enumerated in 1931, and applying to them life tables prepared on the basis of the census of that date, estimates of survivors in 1941 in corresponding age groups have been obtained. Briefly these results are (Punjab, Gwalior, Mysore, Travancore and Hyderabad taken together) :—

	population in millions		difference as percentage of expected
	expected	enumerated	
MALES			
all ages over 10 (in 1941)	22.134	23.710	7.1
ages 10-70, i.e., excluding persons aged 70 and over	21.771	23.180	6.5
FEMALES			
all ages over 10 (in 1941)	19.108	20.965	6.4
ages 10-70, i.e. excluding persons aged 70 and over	19.241	20.410	6.1

Taken individually the error was lowest (0.0% among females aged 10-70) in Mysore and highest (8.7% among females aged 10 and over) in the Punjab. When these methods are applied to the population enumerated in Bengal in 1931 and in 1941, the errors however are considerable :

	males	females
all ages over 10	16.3%	12.0%
ages 10-70 only	15.8%	11.6%

Otherwise the prognosis for 1941, both in the aggregate, and in several age periods, was quite satisfactory. Also the errors are (with one very small exception of 3000 among Hyderabad females aged 70 and over) positive, i.e., enumerated numbers are in excess of expected numbers. One possible or partial cause would be an improvement in vitality occurring during the period 1931-41. The magnitude of the improvement in the chance of survival cannot be determined exactly but was probably appreciable. Life Tables of 1931, for one thing, are obsolete and if we had more appropriate instruments by way of efficient life tables, the differences between expectation and enumeration would probably have been much lower.

(iii) *Reproduction Rates :*

For calculating net reproduction rates the basic data are the ages of mothers at delivery. This was a deficiency even in the U.K. and only by

the Population Act (1936) this gap in knowledge in the U. K. was set right. In India, statistics that can be used for this purpose have been collected since 1940 for cities of 100,000 inhabitants and over in British Provinces and since 1939 in Mysore. But with certain exceptions (the exceptions are Bombay, Ahmedabad, Ajmer and the three cities of Mysore State) delivery statistics cannot be utilised since age distribution tables at 1941 are not available. It is understood that the Government of India will now make good this deficiency.

As we have pointed out in our Report of the Population Data Committee there are also certain other data. Under the initiative of the Census Commissioner for India, a great stride was taken in 1941 Census by way of introducing questions regarding number of children born, and surviving, and the age of the mother at the birth of her first child. It has at any rate been proved that such questions can be asked and will be answered, all over India. These statistics have unfortunately not been fully utilised and the answers obtained to questions of such primary importance regarding fertility and differential fertility in India have not been analysed except in Rajputana, Travancore and Mysore. In the course of the work of the Population Data Committee, it became necessary to examine how far results obtained from these census inquiries and those from vital statistics above referred to are in agreement with each other. These results in respect of Mysore (given below) show striking similarity, and encourage us in the expectation that, if we make good use of our available data, we can get a consistent picture of the reproductive tendencies existing in different parts of the country.

	census inquiries 5133	vital statistics 5177
Total fertility for 1000 married women		
Gross reproduction rates	2.524	2.536
Net reproduction rates	1.282	1.402

(iv) *Y-samples and Complete Enumeration (Vital Ratios) :*

One of the uses to which age tables prepared on the basis of sample slips will be put is the calculation of birth and death ratios. Mortality rates at specified age groups obtained from suitable life tables when applied to the distribution in complete enumeration (C.E.), and to the tabulation based on sample slips (S.E.) in certain eight areas with a total population of 35·50 millions (18·45 millions males, 17·05 millions females) give the following results :—

expected number of deaths in millions			
	males	females	total
C.E.	0.609	0.549	1.158
S.E.	0.605	0.547	1.152

Similarly specific fertility rates derived from the following three experiences (a) Mysore (3 cities 1939-43), (b) Ukraine (1926-27) and (c) Australia (1920-22) give results as under :—

Expected annual births on the basis of experiences (a), (b), and (c)			
	(a)	(b)	(c)
C.E.	931,700	898,811	562,576
S.E.	930,926	936,958	561,780

The largest difference in the birth rates calculated in this way is 1.17 per thousand.

(v) *Y-samples and Complete Enumeration (Parameters of Age Distribution) :*

Elaborate computations were also made to test the representativeness of age tables on sample slips (S.E.) with age tables based on complete enumeration (C.E.) for several Indian States for which both such tables for the census of 1941 were available. Figures for the five statistical constants, mean, standard deviation, variability, and β_1 and β_2 of both the above distributions are given below for Travancore. They show agreement within the limits of sampling error.

	C.E.	S.E.	difference \pm standard error	
MALES				
mean	23.76	23.62	0.14	0.07
standard deviation	18.04	17.99	0.05	0.05
variability	75.90	76.16	0.26	0.45
β_1	0.6156	0.6470	0.0314	0.0113
β_2	2.7943	2.7807	0.0136	0.0217
FEMALES				
mean	23.70	23.73	0.03	0.07
standard deviation	18.02	18.02	0.00	0.05
variability	76.03	75.93	0.10	0.32
β_1	0.6632	0.6641	0.0009	0.0113
β_2	2.8192	2.8009	0.0183	0.1076

Such close agreement was also noticed in respect of the distributions for Rajputana, Bundelkhand, Indore District, and in regard to the distribution of Males in Delhi Province. There were, however, cases where differences in excess of 3 times the standard errors were noticed and accounted through special circumstances. Besides testing difference, we are also able to measure divergence between two distributions presumed to belong to the same group, by means of χ^2 and D^2 . These functions also give differences from their expectation values which are non-significant in relation to their standard errors.

These findings enabled us in the Population Data Committee to conclude that satisfactory projection of population is possible by the use of age tables prepared from sample slips even in the absence of the customary age tables based on complete enumeration.

(II) FAMILY BUDGETS AND CONSUMPTION PATTERNS

Recently over 25,000 budgets of working class families from all over the country were collected to which I had access through the courtesy of the Director, Cost of Living Index, Simla. As an example of the application of analytical methods to such data, consider the question of weights to be assigned to expenditure on food articles by a male (adult), a female (adult), a boy (under 17 years of age) and a girl (under 17 years of age). Denoting by M F B and G the numbers belonging to each category in a family, and by E the expenditure, in rupees, of the family on food articles, the best estimates

of the expenditure, x , y , z and w respectively on account of each class of member of the family, may be derived by the method of least squares from

$$x\Sigma MM + y\Sigma MF + z\Sigma MB + w\Sigma MG = \Sigma ME$$

and three other similar equations.

Since differences are known to exist by place of residence on account of level of prices prevailing therein, and by income level, the data were selected from one centre (DLH) and from income groups (V and VI), Rs. 60-70 and Rs. 70-80 per month, so as to ensure as much homogeneity as possible. Results had also to be produced somewhat rapidly. They were also to indicate the possibility of the statistical method giving a dependable answer from the analysis of family budgets alone, that is, without appeal to the physiological needs of the human body at various stages of development. Hence small samples of 12 and 13 families were decided upon. The work was arranged so as to derive several sets of values for x , y , z , and w , from different samples and to compare the variations in these answers themselves. Also the values so obtained had to be applied to other samples in order to examine how the total expenditure on food articles recorded in the corresponding budgets of these families agreed with estimated expenditure. 75 families (chief member employed in textile and engineering establishments in Delhi) were first used as controls. The solutions of x , y , z , and w from the appropriate normal equations are given below :

serial number of group	number of families in the group	total number in the group of				per capita expenditure in rupees			
		males (adults)	females (adults)	boys (under 17)	girls (under 17)	male (adult) (x)	female (adult) (y)	boy (under 17) (z)	girl (under 17) (w)
1	12	13	14	11	9	15.13	11.41	4.84	6.08
2	12	13	13	12	5	15.21	11.17	5.23	6.12
3	13	14	15	10	9	15.38	11.03	5.29	5.70
4	12	14	15	11	10	15.04	11.30	4.77	5.52
5	13	15	14	11	7	15.28	11.61	5.32	6.03
6	13	15	15	13	8	15.19	11.48	5.11	5.92
total	75	84	86	68	48	15.21	11.35	5.08	5.86

The six different sets of values of x , y , z , and w are remarkably in close agreement. The weighted averages derived from the 6 sets are, for x (the expenditure on account of a male adult) Rs. 15.21, for y (expenditure on account of a female adult) Rs. 11.35, z and w (expenditure on account of a boy and a girl under 17 years of age) Rs. 5.08 and Rs. 5.86 respectively. Expressed in terms of the expenditure on account of a male adult, the weights for the remaining three groups may therefore be taken as 0.75, 0.33 and 0.385.

Having acquired faith through consistency of answer from the six samples used as control, and obtained a system of weights that appears reasonable, the second part of the demand, namely whether these answers could be depended upon in making estimates for other samples, still required to be tackled. Accordingly 7 other sets of samples from the same universe (DLH—Textile and Engineering—Income groups Rs. 60-70 and Rs. 70-80)

covering 90 families were picked up, and estimated expenditure on the assumption that Rs. 15, Rs. 11½, Rs. 5 and Rs. 6 were required as against the weighted averages of Rs. 15.21, Rs. 11.35, Rs. 5.08 and Rs. 5.86, were compared with the expenditure as recorded against them in the budgets.

The following results are obtained :—

On the aggregate, the estimated expenditure of the 90 families (Rs. 3450-4) is only Rs. 3-5, or about one-tenth of one per cent, greater than the recorded expenditure (Rs. 3446-15), paying compliment both to the accuracy of the record and to the power of the estimating method. In smaller groups too, there was good enough agreement between estimate and record—in 4 out of 7 groups the percentage difference is under 5, in one about 7½, and in 2 others between 16 to 20 per cent. Going further down, the agreement between estimate and record in each family also is pretty satisfactory as judged from the frequency table below showing the difference (expressed as per cent of the recorded expenditure).

difference expressed as percent of the recorded expenditure	number of families in which the difference is	
	positive	negative
0 to 4.9	7	7
5.0 to 9.9	8	6
10.0 to 14.9	6	6
15.0 to 19.9	4	2
20.0 to 24.9	7	3
25.0 to 29.9	11	3
30.0 to 49.9	4	12
50 & over.	0	4

In approximately 30% of the families, the error of the estimate was under 10%. In only 4 cases (out of 90) did the estimate differ from the record by 50% or over. Families Nos. 3 and 7 of DLH [vi (a)] with 1 M, 2 F, 1 G in one and 1 M, 1 F, 1 B, 1 G in another, are reported to be spending only Rs. 21-5 and Rs. 22-6 per month on food, against which the estimated amounts Rs. 43-8 and Rs. 37-4 are out by more than 105% and 66%.

Including these two reports which are palpably suspect, the average of the errors of the 90 estimates is only 2.5 per cent. The expectation value of this error is improved to only 0.6% when we exclude these two reports. With these two families excluded, the total estimated expenditure for 88 families is Rs. 3369-8 against the total recorded expenditure of Rs. 3403-4 and the error is just under one per cent.

The results here set out give sufficient proof of the consistency between the six small samples used for control purposes, and the reasonable accuracy with which the estimates reproduce the actual facts in a further sample of 90 families taken in the aggregate, or sub groups of 12 to 15 at a time, or even individually.

It may be stated that although the testing had been done on 90 other families, these families were not only from the same area, from the same industries, and were within the same income group, their composition and average expenditure were also similar.

	no. of families	males	females	boys	girls	total	average no. of members	average expen- diture on food per member (Rs.)
control	75	85	85	68	48	286	3.8	38.4
rest	90	100	105	83	59	347	3.8	38.3

It is unlikely that there will be such close correspondence in general, but the work based on more samples, and with larger sized samples, requires

to be undertaken. In all probability local differences due to income level, or to separate localities may be revealed.

It may also be pointed out that an exhaustive analysis of this material is also likely to throw considerable light on general consumption patterns among these families, in regard to items other than food. The importance of this knowledge in planning and as a guide to manufacturing interests can hardly be exaggerated and one hopes that the data will be fully analysed.

(III) TRAFFIC STUDIES

(i) *Traffic and Factors of Rural Economy—(Sampling Method) :*

Now turning to another subject, it is well known that engineering aspects of roads, such as their alignment, widths, pavements etc. are dependent on the traffic actually passing on the roads, or the traffic that may be expected to pass on them. But traffic density in turn is dependent on the population and produce, on commerce and industry, on wealth and activity, present, or to be created, in those areas. The determination of the exact nature of relationship between traffic density on one side, say T tons per day, and the several variables that contribute to the traffic, say N persons, P bushels of produce, V rupees worth of commerce, etc., is the main object of another investigation. The usefulness of this determination while embarking on large schemes of expansion is obvious.

Adopting the methods of factor analysis, the first stage of the work is to obtain correlation tetrads of T with N, P, V and all other variables selected for the purpose, and to assess the specific contribution to T by each. With a knowledge of the saturations along each of these axes, it should be possible to construct a yard stick whereby some approximate estimate can be made of T for given changes in the known totals of N, P, V and other variables. The factual data on which this theory can be worked out are of course actual counts of traffic and of field conditions. It is impossible to undertake such studies for the whole length and breadth of the vast continent. The only feasible method is that of well selected representative sampling. Such study has however not yet been completed. As a preliminary thereto it may be interesting to know the scope of the sample method for traffic counts in a fairly busy centre in Calcutta very near the Presidency College. A 24-hour census (on 6th-7th February 1945) of the traffic moving east to west covering 2979 vehicles may be compared with the results obtained by amplifying the total traffic ascertained in a limited period of time by a suitable multiplier. The actual periods of time to be selected for the sample is a difficult problem. For instance, if only 4 hours' watch of traffic is agreed upon, the four hours can be selected in over ten thousand different ways, and the representativeness or otherwise of the sample will obviously depend on the particular set of 4 hours chosen. The total traffic during the four hours (08-09 ; 14-15 ; 20-21 ; 02-03 ; Set A) covering 485 vehicles gave a nearer estimate to the day's total than did the sets (09-10 ; 15-16 ; 21-22 ; 03-04) 519 vehicles, (09-10 ; 11-12 ; 15-16 ; 17-18) 934 vehicles. Not only did the first set A yield the least difference in total traffic but the differences between enumerated total traffic for the day and the corresponding estimated total traffic among 7 vehicle types (rickshaw, *thela*, cycle, cart, coach, tram and lorry) comprising nearly 85 per cent of all traffic, were within 3 times the standard error of the difference on the binomial probability law, and therefore the fluctuations may be attributable to chance. The categories bus, car, and "rest" showed, however, differences which exceeded 3 times but not 4 times the standard error. Likewise too, the differences between enumerated totals

and estimated totals in the categories, "medium load" and "empty", were within sampling errors, whereas the similar differences in "light load" and "heavy load" were significant. The chi-squares based on the distribution of 10 categories of vehicles was the lowest with set A, and gave a value of P of the order 0.90. It is accordingly claimed that a sample set can be discovered to represent the day's traffic either in terms of the total only, or in terms of its distribution by vehicle type or load, but that a sample representative in one regard may be more representative or less representative in other regards.

As another example, we may refer to the total bullock cart traffic carrying commodities moving into Gaibandha (Bengal) during the 24 hours of the day (June-July, 1945).

commodity	number of carts	per cent of total
jute	533	57.9
paddy	49	5.3
rice	134	14.6
pulses	55	6.0
vegetables etc.	80	8.7
firewood and bamboo	40	4.3
rest	29	3.2
all commodities	920	100.0

An investigation was made whether the above pattern of traffic could be reproduced, both in volume and in variety, exactly or as closely as possible in any shorter period. To this end, 24 intervals of one-hour traffic, 12 intervals each of two-, four-, six and twelve-hours traffic divided in to two equal half intervals separated by twelve hours, and finally 24 continuous 12-hour intervals were tested. Only in 23 intervals did the actual traffic lie within 10 per cent of the proportionate traffic due for that interval, and only in 3 of them (all 12-hour intervals) was the traffic pattern in respect of commodities reproduced. The latter intervals, and the degree of agreement in them, were as below :—

interval (hours)	duration	standard error of difference between actual and proportional traffic	chi-square	probability of exceeding observed chi-square
09-15 and 21-03	12	1.87	3.13	.80
08-14 and 20-02	12	1.76	2.59	.85
09 to 21	12	1.60	2.78	.84

It thus appears that a 12-hour watch, preferably divided into two 6-hour intervals, separated by half a day is necessary. Extensive research is obviously necessary before a fully representative short period can be discovered and even then, it is doubtful if such a sample will universally apply to all seasonal and regional fluctuations.

(ii) *Control Chart Method :*

Some data are available of traffic censuses taken at half yearly intervals recording, *inter alia*, tonnage of vehicular traffic moving at several count stations selected in several districts. For instance, figures relating to traffic census for April 1940 along 40 roads are available for Chittoor District (Madras Presidency). It is required to find whether such extensive census taking was necessary, or fewer count stations would do. The total tonnage moving along these 40 roads is 12,311 per day, or 308 tons per day per road on the average. The range however is 681 tons, the lowest recorded on a road being 58 and the largest 739, and the variance is 33,047. Taking the records in the serial order in which they are published, the mean of the arithmetic mean, the range, the variance obtained by selecting samples 4, 5, 8 and 10 at a time, results given in the table below were obtained.

size of sample	number of samples	mean of the sample means	mean of the ranges	variance
1	40	308	681	33,047
4	10	308	334	13,857
5	8	308	374	13,857
8	5	308	456	12,357
10	4	308	488	11,174

The mean of the sample means will of course be the same and agree with the grand mean (308). The variance falls down to 2/5ths, when the sample size is 4, and thereafter falls very slowly even when the sample size is 10. This means that as much of the information as possible is secured even when a sample of 4 roads is surveyed, nothing further is seemingly gained when a fifth road is added, and very little more is gained when 8 or 10 roads are included in the survey and the labour and cost of the survey are increased twofold or more. It will not be understood that 4 roads are the optimum number for each district, or for catching all classes of traffic, but the method of analysis corresponding to Bartel's technique for time series (*Jour. Amer. Stat. Assn.* June 1940, pp. 347-361) will give an indication whether the items in the universe are independent of one another, and how many items in the sample are required to be included for securing a sufficiently homogeneous or stable sample.

The method of control charts used in quality control analysis is also serviceable for answering the question whether samples of a given size show, or do not show, variations large enough to have been produced by identifiable causes. With the Chittoor district data (April 1940) discussed above, the grand mean is 307.8, the mean of the ranges is 333.6 (samples of size 4), and accordingly the control limits are $307.8 \pm 0.729 \times 333.6$ (on criterion 3), namely, 551 and 65. All the sample means lie between these upper and lower limits.

Whilst this is so on taking the whole of the traffic, it is not so when motor vehicle traffic alone is being estimated. In the published detailed traffic census the tonnage carried on motor vehicles is also separately shown. For the same group of 10 samples of 4 roads each, the sample means are 294 ; 273 ; 95 ; 99 ; 47 ; 73 ; 38 ; 46 ; 35 and 62 tons. The upper and lower control limits are $105 \times 0.729 \pm 107.2$, namely 183 and 27. Clearly the roads in the first two samples are differentiated with respect to motor vehicle traffic, and there is some identifiable cause for variation in the terminology

of industrial production. Actually these count stations are along Madras—Bombay Trunk Road with tar sprayed pavement, or premix macadam with socony emulsion pavement to which quite naturally the motor vehicle is more attracted. Thus it is to be observed that whilst a group of 4 roads will suffice for cart traffic observation, any four roads do not suffice for estimating motor traffic.

(iii) *Method of Least Squared Differences :*

As a final example, consider the question of ascertaining the shares of the total maintenance costs of a road that may be allocated to motor vehicle traffic (say P , denoting the average daily weight in tons of such traffic), and to all other types of vehicles (say Q , denoting the average daily weight in tons of steel-tyred and wooden-tyred traffic). The damage done by the latter is understood to be considerably larger than that by the former, but what precisely is the ratio has not been stated on factual data. It is true that besides traffic density, other factors known as capacity variants in contrast with traffic variants less amenable, or not at all amenable, to statistical evaluation, viz., soil condition, quarry location, weather factor, future life time of surface paint, etc., enter into the cost. But confining the problem to traffic density, the most hopeful method for determining X and Y , unit costs for each ton of the two types of traffic, is by the application of the method of least squares. Accordingly, as a control, the homogeneous tract of 4 districts known as Ceded Districts in Madras was selected, and the traffic census on 12 feet wide water-bound macadam surfaced roads, with maintenance costs as recorded in the summer of 1940 were analysed. The results given by this preliminary analysis are $X = -0.0544$ Rs. and $Y = 1.6690$ Rs. A negative value for X (cost arising on account of a ton of motor vehicle traffic) need not cause surprise, or loss of faith, in the method of statistical analysis. What it implies is that there is something unsound in imposing the whole cost (C) of maintenance on traffic alone. Here it is where the statistician should be on his guard. He should take note of the fact that in building up (C), factors other than traffic, (namely the four other factors of soil condition, quarry location, weather, surface life above referred to), are exercising their influence. We have, therefore, to repeat our work not with recorded costs C , but on "adjusted" costs (γ). It is not easy to get the relation between C and γ , but tentatively assuming that fixed costs were Rs. 100 per road, and that weathering, soil condition etc., are responsible for a fifth part of C ,

$\gamma = 0.80X(C-100)$. This assumption appears justifiable on results. Other formulae determining the proportion between capacity variants and traffic variants of cost based on different technical grounds may be tried. Working now with P , Q and γ , we obtain as the best estimates by the method of least squared differences, $X = 0.2272$ Rs. and $Y = 0.9225$ Rs.

These results are in any case clear of nonsense negative values, and appear to be reasonable as dimensional estimates, namely that a ton of non-motor vehicle traffic (NMV) is about 4 times as damaging to the road as a ton of motor vehicle traffic (MV) when the composition of the traffic is MV to NMV as 1 to 2, that being nearly the ratio found in the control data. The rider "when the composition of traffic is MV to NMV is 1 to 2" is very important as will be seen presently.

Having obtained as a working hypothesis that X is 0.2272 Rs. and Y is 0.9225 Rs., we would like to test the validity of the formula on the costs of maintenance of similar roads (viz. 12 feet water bound macadam surfaced

roads in 16 other districts in Madras Presidency, April 1940 levels). The results of the comparison are given below :—

	number of districts	number of roads	tons of MV traffic	tons of NMV traffic	total cost in rupees recorded by PWD (A)	estimated (B)	error (A-B)	percentage error $\frac{100(A-B)}{A}$
control check	4 16	33 343	4,227 63,912	8,879 124,659	— 197,413	— 196,204	— 1,209	— 0.6

The error (costs as recorded less costs as estimated), is Rs. 1,209, or 0.6 per cent, and is insignificant fraction. Among individual districts the percentage error varied from—26% to 31%. In 5 districts (of which one belonged to the control group) the error is under 10%, in 6 districts (of which two belonged to the control group) the error is between 10 and 15 per cent, and in 6 districts (of which one belonged to the control group) the error is between 15 and 30 per cent, and in 2 districts the error exceeded 30 per cent.

But on technical grounds the estimated costs require to be correlated for one more factor, namely the proportion of MV traffic in the total mixed traffic. Correlational analysis between the error (e), and the proportion (p), showed that r_{ep} was of the order 0.49, and that as p tended to increase beyond 37, e tended to be positive and large. In other words, a correlation of the order of 0.8 per cent of cost for every 1 per cent, the proportion of MV traffic differed from 37, had still to be applied.

To make the idea precise the following two examples are given :—

	Coimbatore Dt.	Malabar Dt.
1. proportion of M V traffic to total traffic	23	69
2. difference from the critical level of of 37 per cent	— 14	+ 32
3. 0.8 times the above difference	— 11.2	+ 25.6
4. statistical estimate of cost	Rs. 12,088	Rs. 5,138
5. applying correction (as in 3)	— Rs. 1,354	+ Rs. 1,315
6. revised statistical estimate	Rs. 10,734	Rs. 6,453
7. recorded costs by the P.W.D.	Rs. 10,592	Rs. 7,319
8. present error	+ Rs. 142 (1%)	— Rs. 866 (12%)
9. previous error obtained before correction for the proportion of MV traffic was applied	+ Rs. 1,496 (14%)	— Rs. 2181 (30%)

The general conclusion may now be stated in the following terms. :

On 12-foot roads with water bound macadam surface in Madras Presidency where the average annual costs of maintenance of a mile of road in summer is about Rs. 500 (actually Rs. 470), an estimate of cost can be built up from observed traffic density,

- (1) at the rate of about Rs. 25 (actually Rs. 22.72) per 100 tons of MV moving daily and
- (2) at the rate of about Rs. 100 (actually Rs. 92.25) per 100 tons of NMV moving daily,
- (3) increasing this total first by 25 per cent on account of weathering and other variable conditions affecting maintenance costs, and

- (4) further increasing by a constant sum of Rs. 100 to represent fixed costs,
- (5) and finally adding (or subtracting) 0.8 times the percentage by which the MV fraction exceeds (or falls short of) 37 per cent, on account of the difference in composition of mixed traffic.

It should however be stated that the recorded costs of maintenance are only the amounts spent for the purpose under various conditions of exigency. They may not truly measure the repair needed for the physical deterioration caused by different types of traffic, such as may be indicated by experimental work on test tracks.

TRAINING OF STATISTICIANS

Recent opportunities for the extension of statistical research have forcibly brought to light the acute shortage of suitably trained persons and the paucity of college teachers who have sufficient profundity and versatility to cover every conceivable application of such methods daily growing in momentum. Universities, not only Indian Universities, are still undecided whether statistics should be affiliated to the mathematics, economics, or commerce schools, when the obvious course is to establish a school for statistics itself. Many universities are still content to give a course in "descriptive" statistics, or interpolation and graduation, or even of moments of frequency distributions and correlation. The power and scope of statistical methods comprise empirical logic and estimation, and a course that fails to comprehend stochastic reasoning and fiducial probability does far less justice to a student of statistics than is expected of a student supplicating for a modern Master's degree in any other science subject. We cannot expect a sudden burgeoning of statistical curricula in our universities unless an independent department is created for statistics and by its own work and worth, peaceful penetration into the departments of economics, psychology, education, agriculture and medicine is rendered possible by mutual contact and break-up of resistances. This is not enough. Statistics is essentially an applied subject, and the courses of instruction should cover sufficient field work in diverse subjects, computation practice and technical skill in the actual handling of project work. Perhaps the University may not in itself be able to provide all these opportunities for sound theoretical education and training for a professional career. Learned societies, e.g., the Royal Statistical Society in Great Britain, are contemplating the creation of facilities for training, examination and research, under their own auspices thus securing at one and the same time proper equipment, vocational guidance and professional status. "The status of the statistician," says Dr. Snow (Presidential Address to the Royal Statistical Society, 21 March 1944), "should be of great concern to the administrator. The former should be as valuable to the latter as the skilled advocate is to the judge in a High Court. In each case the one provides the other with materials for decision and judgment." In achieving this consummation, statutorily established universities, non-official institutes and laboratories have a large and important part to play before the training of the statistician is well planned, and the recruiting, classification and the placing of the statistician in Government service and industry are well settled. To remedy a wrong step taken in such matters takes a generation, and we in this country have woeful examples of such indiscretions.

JOB OPPORTUNITIES

The role of the statistician outside Government or organised industry is equally important. Smaller business organizations, relief societies, public

associations and political parties are equally anxious to have either continuous statistical service, or proper presentation or reporting of isolated inquiries by them on subjects of topical or exclusive interest. A stock broker, an insurance company, a banking house, would very well afford a statistician to guide and assist them. Job opportunities so arising may create for a consulting statistician a position of advantage and lucrative practice no way inferior to that of a consulting engineer, actuary or medical specialist. Economist's index of cost of living, British Textile Industry's Statistical set-up, Gallup polls, Bell Telephone Company's statistical section, Metropolitan Life Insurance Company's statistical service, National Bureau of Economic Research, Cowles Commission for Economic Research are examples from the U.K. and the U.S.A. of such statistical services and opportunities. In this country also, financial newspapers, chambers of commerce and perhaps certain large industrial establishments have their own statistical sections, but regular publication of indexes and technical analysis of statistical data should create opportunities for job work. No doubt they would create great responsibilities as well and the most successful way of meeting them would be by setting of professional standards, either statutorily or by mutual consent.

IMMEDIATE NEEDS

Furthermore, frequent contacts and interchange of views among statisticians in the country and outside are urgent requirements. Such international conferences and short visits of people—younger people, more particularly—from this country to foreign countries and of foreign savants to this country are foreshadowed in several other departments of learning and of business. In the field of statistics, the need for circulation is even greater, since usually in statistical research there is emphasis on the national aspect, for example, research is largely confined to national income, national production, national welfare etc. and an early and proper stress on the international viewpoint in statistics and statistical methods is both desirable and necessary. In the view of the President of the Royal Statistical Society (Snow, March 21, 1944), a new organization (apart from the International Statistical Institute existing before the War at the Hague) should be formed to approach international statistical problems in a more realistic manner. The pan-American countries have already so united themselves and the *Estadística*, their official publication, has shown the scope and utility of such an organization. It is admitted that the future safety of the world is through international understanding and agreement, and the first stage towards any agreement is a thorough mastering of all the relevant "facts". This is the statistician's power and privilege, and surely, even if slowly, the statistical method is getting woven into the very fabric of all our thoughts and activities.

Wrote George Sarton in his biography of the great Belgian Statistician, Adolphe Quetelet (Quoted in *Jour. Amer. Stat. Assn.* Vol. 40 (229) p. 10), "I like to think of the constant presence in any sound Republic of two guardian angels; the statistician and the historian of science. The former keeps his finger on the pulse of humanity and gives the necessary warning when things are not as they should be. . . . the statistician is like a physician humanity must be protected by the watchful statistician, and it must be sustained in its newer and bolder efforts by the consciousness of every antecedent effort to which it owes its culture, its dignity and its excellence."

SECTION OF PHYSICS

PRESIDENT : PROF. S. BHAGAVANTAM, HON. D.Sc., F.A.Sc.

ELASTIC CONSTANTS OF CRYSTALS

(Delivered on 4 January, 1946)

INTRODUCTION

The discovery of the Raman effect has placed in the hands of the experimental physicist a very powerful tool for investigating, amongst other things, the nature of the solid state. Systematic attempts at obtaining detailed experimental data and correlating them with the known crystalline properties have resulted in some significant advances being made in the past few years. Much useful information regarding the crystalline force fields has been obtained. While engaged in these studies, it was felt by the author that a detailed experimental and theoretical study of the elastic behaviour of crystals would go a long way to complete the picture. A review of the literature showed that a good deal of work can be done only if proper methods are developed. Attention was accordingly directed towards the development of a suitable technique. The success that has attended our efforts in this direction has enabled us to study many simple crystals. In this address, I shall confine myself to a discussion of the technique and the results obtained from it.

STRESS-STRAIN RELATIONS

We are concerned here with the macroscopic behaviour of crystals and as such it would be useful to recall to our minds the main features of the classical theory of elasticity. It is based on the following important assumptions.

- (a) The crystal is regarded as absolutely homogeneous and ideal, imperfections being altogether absent. This permits us to work with time and space averages.
- (b) The deformation is regarded as homogeneous and effects of plasticity are neglected. Voigt has shown that under these assumptions stress and strain can be looked upon as symmetric tensors of the second order.
- (c) We assume that Hooke's law holds good. This assumption implies that elastic hysteresis effects do not occur.

Thus the components of stress are

$$\begin{array}{ccc} K_{xx} & K_{yx} & K_{zx} \\ K_{xy} & K_{yy} & K_{zy} \\ K_{xz} & K_{yz} & K_{zz} \end{array}$$

with $K_{ij}=K_{ji}$. The components of strain, U_{xx} , U_{xy} etc., are written in a similar manner.

Hooke's law in its generalized form states that every component of stress at any point in a body is a linear function of the components of strain at that point. Thus a stress component K_{xy} is given by the following relation :

$$K_{xy} = C_{xyxx}U_{xx} + C_{xyyx}U_{yx} + C_{xyzx}U_{zx} \\ C_{xyxy}U_{xy} + C_{xyyy}U_{yy} + C_{xyyz}U_{yz} \\ C_{xyxz}U_{xz} + C_{xyyz}U_{yz} + C_{xyzx}U_{zx}$$

The first two letters of the subscripts on the constants refer to a component of stress and the next two to a component of strain. It is usual to replace the subscripts x, y, z by 1, 2, 3 respectively and the pairs of subscripts 11; 22; 33; by 1; 2; 3; and the pairs 23; 31; 12 by 4; 5; 6. It must be noted that 4, 5, 6 can also replace 32, 13 and 21 respectively on account of the fact that $U_{ij} = U_{ji}$ and $K_{ij} = K_{ji}$. We now write all the stress components in terms of the strain components.

$$K_{xx} = C_{11}U_{xx} + C_{12}U_{yy} + C_{13}U_{zz} + 2C_{14}U_{yz} + 2C_{15}U_{zx} + 2C_{16}U_{xy} \\ K_{yy} = C_{21}U_{xx} + C_{22}U_{yy} + C_{23}U_{zz} + 2C_{24}U_{yz} + 2C_{25}U_{zx} + 2C_{26}U_{xy} \\ K_{zz} = C_{31}U_{xx} + C_{32}U_{yy} + C_{33}U_{zz} + 2C_{34}U_{yz} + 2C_{35}U_{zx} + 2C_{36}U_{xy} \\ 2K_{yz} = 2C_{41}U_{xx} + 2C_{42}U_{yy} + 2C_{43}U_{zz} + 4C_{44}U_{yz} + 4C_{45}U_{zx} + 4C_{46}U_{xy} \\ 2K_{zx} = 2C_{51}U_{xx} + 2C_{52}U_{yy} + 2C_{53}U_{zz} + 4C_{54}U_{yz} + 4C_{55}U_{zx} + 4C_{56}U_{xy} \\ 2K_{xy} = 2C_{61}U_{xx} + 2C_{62}U_{yy} + 2C_{63}U_{zz} + 4C_{64}U_{yz} + 4C_{65}U_{zx} + 4C_{66}U_{xy}$$

The constants C_{ij} are the elastic constants defining the characteristic behaviour of the body. On the definition of the stress and strain given here, the elastic constants are the 81 terms defining the relations between the nine components of each of the two second order tensors. On account of the symmetric nature of the tensors, certain of these constants become equivalent and thus the number is reduced to 36. The numerical factors attached to the constants in the above equations arise on this account.

Further, in view of the fact that elasticity is a centro-symmetric property, $C_{ij} = C_{ji}$ and the number of elastic constants is reduced from 36 to 21. We require 21 independent elastic constants to describe the behaviour of a triclinic crystal. The presence of symmetry elements of a higher order in a crystal imposes additional conditions resulting in further relationships between the various constants. When these are taken into account, the 32 crystallographic point groups regroup themselves into 9 divisions which are elastically distinct. They have been enumerated by Voigt and by others using different methods.

PROPAGATION OF SOUND THROUGH CRYSTALLINE MEDIA

The method developed by the author is based on a determination of the normal modes of a crystal plate performing elastic vibrations. It is possible to make such determinations by studying the passage of sound waves through them. This is a classical problem which has been solved by a number of workers. Considering the sound wave as a disturbance of a general character, Love has given a very good treatment of the subject. The velocity v , of propagation of sound in a direction $Z'(\alpha_{13}, \alpha_{23}, \alpha_{33})$, is given by the determinantal equation :

$$\begin{vmatrix} \lambda_{11} - \rho v^2 & \lambda_{21} & \lambda_{31} \\ \lambda_{12} & \lambda_{22} - \rho v^2 & \lambda_{32} \\ \lambda_{13} & \lambda_{23} & \lambda_{33} - \rho v^2 \end{vmatrix} = 0$$

where ρ is the density of the crystal and the λ 's are functions of the elastic constants.

$$\begin{aligned}\lambda_{11} &= C_{11}\alpha_{13}^2 + C_{66}\alpha_{23}^2 + C_{55}\alpha_{33}^2 + 2C_{56}\alpha_{23}\alpha_{33} + 2C_{15}\alpha_{33}\alpha_{13} + 2C_{16}\alpha_{13}\alpha_{23} \\ \lambda_{21} &= C_{16}\alpha_{13}^2 + C_{26}\alpha_{23}^2 + C_{45}\alpha_{33}^2 + (C_{46} + C_{25})\alpha_{23}\alpha_{33} + (C_{14} + C_{56})\alpha_{33}\alpha_{13} \\ &\quad + (C_{12} + C_{66})\alpha_{13}\alpha_{23} \\ \lambda_{31} &= C_{15}\alpha_{13}^2 + C_{46}\alpha_{23}^2 + C_{35}\alpha_{33}^2 + (C_{45} + C_{36})\alpha_{23}\alpha_{33} + (C_{13} + C_{55})\alpha_{33}\alpha_{13} \\ &\quad + (C_{14} + C_{56})\alpha_{13}\alpha_{23} \\ \lambda_{22} &= C_{66}\alpha_{13}^2 + C_{22}\alpha_{23}^2 + C_{44}\alpha_{33}^2 + 2C_{24}\alpha_{23}\alpha_{33} + 2C_{46}\alpha_{33}\alpha_{13} + 2C_{26}\alpha_{13}\alpha_{23} \\ \lambda_{32} &= C_{56}\alpha_{13}^2 + C_{24}\alpha_{23}^2 + C_{34}\alpha_{33}^2 + (C_{44} + C_{23})\alpha_{23}\alpha_{33} + (C_{45} + C_{36})\alpha_{33}\alpha_{13} \\ &\quad + (C_{46} + C_{25})\alpha_{13}\alpha_{23} \\ \lambda_{33} &= C_{55}\alpha_{13}^2 + C_{44}\alpha_{23}^2 + C_{33}\alpha_{33}^2 + 2C_{34}\alpha_{23}\alpha_{33} + 2C_{35}\alpha_{33}\alpha_{13} + 2C_{45}\alpha_{13}\alpha_{23}\end{aligned}$$

The above equations, usually termed the Christoffel's equations, yield three real and positive roots for v^2 . There are accordingly three wave velocities associated with any direction of propagation. If we solve these equations and write down the modes of vibration of the solid corresponding to these three values of v^2 , they will describe fully the displacement vectors in respect of the three waves that can be associated with the three wave velocities. If we consider only plane waves, Green has shown that the displacement vectors are mutually orthogonal.

We will first solve Christoffel's equations for the case of isotropic substances. If we regard the Z' direction as the direction of propagation, we get the following normal modes in which $a_x' = a_y' \neq a_z'$.

$$a_x'(C_{44} - \rho v^2) = 0; \quad a_y'(C_{44} - \rho v^2) = 0; \quad a_z'(C_{11} - \rho v^2) = 0$$

These results show that there is a pure longitudinal wave and that the corresponding wave surface is a sphere. The two shear modes are also pure but the corresponding wave surfaces are spherical and coincident.

In crystalline substances, the Christoffel's equations do not generally split up and the modes describing the propagation of the three waves are all coupled. In certain classes and along specific directions, the equations do split up and the normal modes are independent. For example, in the case of cubic crystals and along directions perpendicular to (001), (011) and (111), it may be verified that such is the case.

ELASTIC VIBRATIONS OF CRYSTAL PLATES

Koga has considered this problem. Following him, we shall restrict our attention to non-piezoelectric plates and take a plate of thickness d and infinite lateral dimensions. Let us suppose that a sound wave of frequency f is started at the first surface. On reaching the second surface, part of the acoustic energy is reflected and part is transmitted. Given suitable conditions, the reflected wave in conjunction with the incident wave forms a standing wave. Obviously the condition is $v = 2df$, where v is the velocity of propagation of sound. Under such circumstances the plate can be said to resonate to the frequency f . From what has been said in the previous section, it is clear that a crystal plate generally resonates to three frequencies f_1 , f_2 and f_3 ; f_1 corresponding to the longitudinal or the quasi-longitudinal

mode and the other two to the shear or quasi-shear modes. The plate can then be regarded as performing thickness longitudinal or thickness transverse vibrations. Thus, it may either be looked upon as a generator of the corresponding frequencies or as a medium capable of transmitting sound possessing those frequencies with the highest efficiency.

It is now clear that if we can find a suitable means of generating an acoustic beam of continuously varying frequencies and having a reasonably constant output of sonic intensity, then we can employ it to pick out the above mentioned transmission maxima.

A determination of these frequencies permits us to evaluate the characteristic values of n for the thickness direction and hence enables us to calculate the corresponding elastic constants. A sufficient number of such determinations with plates of different thickness directions will enable us to determine the independent elastic constants characterising the behaviour of the crystal as a whole.

A finer aspect of the problem relates to the effect of the boundaries of the plate. Recently Ekstein has considered this aspect by employing perturbation methods. The special cases considered by him are extensional vibrations and not the thickness ones. In the investigations described in the present address, care is taken to see that the lateral dimensions of the crystal plates are large compared to their thickness resulting in the corrections, if any, falling well within the limits of experimental error.

With crystals of lower symmetry the longitudinal and transverse modes will invariably be coupled and hence difficulties arise in making numerical calculations for evaluating the elastic constants. In such cases, approximate solutions of Christoffel's equations can be written down and usefully employed.

THE WEDGE METHOD

The main feature of our technique is the realisation of a source which gives an ultrasonic beam of continuously varying frequencies and having an output which falls gradually with increase in frequency. It is very well known that plane parallel plates of piezo-electric crystals when used in oscillator circuits act as generators of monochromatic frequencies. On the other hand, the use of a piezo-electric wedge changes the situation altogether. As the exciting frequency of the electrical circuit is varied, an appropriate portion of the wedge responds to the electrical frequency and generates an ultrasonic beam of the same frequency. Thus it is possible to obtain a continuous band of ultrasonic frequencies. The width of the band depends upon the dimensions of the wedge. The lower limit is determined by the maximum thickness of the wedge and the upper limit by the power of the driving circuit, the sensitiveness of the detecting device and the breaking stress of the crystal employed. In our experiments, three different wedges were used. Quartz I had a range of 1.4 to 5.0 Mcs, Quartz II a range of 2.0 to 6.0 Mcs and the Tourmaline wedge had a range of 2.5 to 11.0 Mcs. One of these wedges is laid on a crystal plate whose orientation is known and the frequency of the electrical circuit is varied till at a certain value the sound wave is transmitted to a maximum extent.

These transmission maxima are detected and measured in the following manner. The crystal plate and the wedge are mounted in a specially designed holder. It consists of an annular brass plate electrode secured by a brass rod to an ebonite plate. The crystal plate under investigation is laid on this electrode. The wedge is placed on the specimen using a film of oil for securing good acoustical contact. On the top of the wedge is placed a small brass

disc and the whole arrangement is held pressed lightly against the brass plate by a fine spring. This spring functions also as the second electrode. The entire set-up is mounted on another ebonite plate and is provided with spring-loaded levelling screws to facilitate accurate alignment. The arrangement is then dipped into a rectangular cell containing a liquid like carbon tetrachloride. The ultrasonic beam from the wedge passes through the crystal and then enters the liquid. A beam of light with the usual optical arrangements is made to pass through the ultrasonic grating set up in the liquid, and the Debye-Sears diffraction effects are observed. Since the sound beam is best transmitted when the frequency of the wedge corresponds to the fundamental or an overtone of one of the normal modes of the crystal plate, the Debye-Sears pattern will have a maximum intensity at such points. In practice it has been found that the setting for maximum transmission is very sharp and is capable of being reset to within 1 or 2 per cent. The transmission frequency is then measured with an accurate wave meter.

Transmission maxima thus recorded have to be sorted out and assigned to their appropriate modes. From what has already been said it is easy to see that the thickness longitudinal modes produce a large ultrasonic grating in the liquid with the result that the number of diffraction orders as well as the intensity of each diffraction order will be quite large. On the other hand, in the case of transverse and quasi-transverse modes, they can be transmitted into the liquid medium only as longitudinal vibrations consequential to either inherent coupling or edge coupling. Hence these transmission frequencies produce weak gratings in the liquid medium and the diffraction effects will show correspondingly low intensities. These distinctions furnish a criterion by which the transmission maxima can be sorted and associated with their corresponding modes. As an example, I give below an observation sheet.

TABLE I

MEASUREMENT ON GALENA : (110) PLATE : $d=1.56$ mm. $\rho=7.560$

Transmission Maximum Mcs.	Intensity	Mode		
		Longitudinal	Shear (1)	Shear (2)
2.82	w	—	—	0.564×5
3.10	w	—	0.775×4	—
3.39	w	—	—	0.565×6
3.64	v.s.	1.213×3	—	—
3.90	w ₁	—	0.780×5	(0.557×7)
4.46	w	—	—	0.558×8
4.64	f.s.	—	0.773×6	—
4.86	s	1.215×4	—	—
5.18	w	—	—	0.576×9
5.49	w	—	0.784×7	—
5.64	v.w.	—	—	0.565×10
6.00	s	1.200×5	—	—
6.18	w	—	0.773×8	—
6.86	w	—	0.762×9	—
7.26	s	1.210×6	—	—
Average fundamental		1.210	0.775	0.564

Shear (1) corresponds to a mode with a velocity $2d \times 0.775 \times 10^6$ equal to $\sqrt{C_{44}/\rho}$ and shear (2) to a mode with a velocity $2d \times 0.564 \times 10^6$ equal to $\sqrt{(C_{11}-C_{12})/2\rho}$. The longitudinal wave has a velocity $2d \times 1.210 \times 10^6$ equal

to $\sqrt{(C_{11} + C_{12} + 2C_{44})/2\rho}$. The table clearly shows the method of identification employed. Occasionally some of the overtones may be apparently missing but this is due to an overlapping with other modes. An example of this type is enclosed in brackets in Table I. The frequency values listed in this table are averages of a number of observations. The elastic constants C_{11} , C_{12} and C_{44} obtained from these observations for galena are given in Table II.

NATURE OF THE MATERIALS USED

Requirements of theory and the limitations of the experimental methods so far in use impose very stringent conditions on the nature of the materials that can be used. Firstly, the crystal should be homogeneous in structure and free from impurities and imperfections. In some cases, by artificial methods of growing, large and homogeneous crystals free from impurities can be obtained. The real difficulty comes in tackling imperfections, which are mainly mechanical in nature. Fissures, crevices, slip lines and twins come under this category. These may be produced either during or after the formation of crystals. Very often it is these unsuspected faults that vitiate the results. In actual practice, it has been found by us that the superiority of the wedge method over the others lies here. A number of plates containing small cracks etc. have been examined and they were found to yield results accurate to within 3 per cent. We have also found that this method is particularly valuable when only small sized specimens are available. In the case of crystals like diamond, we are obliged to work with plates not very much larger in size than 5 mm. along each edge. Even under such conditions, the method has given valuable results.

MEASUREMENTS ON SOME CRYSTALS

Results obtained in the author's laboratory by applying the wedge technique to some cubic crystals are given in Table II. Results obtained in hexagonal and trigonal crystals similarly studied are given in Table III. The results given for the cases of quartz and zinc blende have been, however, obtained after combining the measurements by the wedge method with those obtained by other methods.

TABLE II

ELASTIC CONSTANTS OF CUBIC CRYSTALS

Substance	C_{11}	C_{12}	C_{44}
Zinc Blende	10.79	7.22	4.12
Galena	8.69	4.01	4.42
Iron Pyrites	36.2	-4.64	10.52
Diamond	95.0	39.0	43.0
Rock Salt	4.97	1.27	1.27
Flourite	16.44	5.02	3.47

(Units are 10^{11} dynes/cm².)

TABLE III

ELASTIC CONSTANTS OF HEXAGONAL AND TRIGONAL CRYSTALS

Substance	C_{11}	C_{33}	C_{44}	C_{12}	C_{13}	C_{14}
Apatite	16.67	13.96	6.63	1.31	6.55	—
Quartz	8.69	10.68	5.76	0.69	1.56	1.74
Calcite	13.74	8.01	3.42	4.40	4.50	-- 2.03
Sodium Nitrate	8.67	3.74	2.13	1.63	1.60	0.82

(Units are 10^{11} dynes/cm².)

Values given in Tables II and III agree very well with those of other workers in substances like rock salt, quartz and fluorite, which have already been studied by the application of the usual static and dynamic methods. It is interesting to note here that measurements on pyrites confirm the values of Voigt. The extraordinary behaviour of this substance consists in its exhibiting a negative value for C_{12} and this has to be explained on the basis of its internal structure and force fields.

BORN'S THEORY AND ITS VERIFICATION

Born has developed a theory of the elasticity of crystals from the atomic standpoint. He has shown that the elastic constants of a crystal can be calculated if the force field is known because the force field permits us to write down the potential energy function and the elastic constants are merely suitable sums of the derivatives of the potential energy function taken over the whole lattice. With a little effort and following Born's theory, one can obtain the following expressions for the elastic constants of diamond :

$$C_{11} = \frac{1}{3d} \left[K_1 + 12K_\alpha + 12K_\beta \right]$$

$$C_{12} = \frac{1}{3d} \left[K_1 - 6K_\alpha + 6K_\beta \right]$$

$$C_{44} = \frac{1}{3d} \left[\frac{72K_1K_\alpha}{4K_1 + 32K_\alpha} + 6K_\beta \right]$$

d is the side of the unit cube, K_1 is the force constant referring to any pair of atoms which constitute the nearest neighbours, K_α is the force called into play when the angle between any two valence bonds which meet at an atom varies, and K_β is the force constant referring to the next nearest neighbours. Diamond is very well suited for the verification of the theory but data on individual elastic constants were hitherto not available. However, the evaluation of the force constants K_1 , K_α and K_β could be effected only recently after a thorough investigation of the Raman spectrum and the normal oscillations of this crystal. If the diamond structure is regarded as built up of units with 16 atoms per cell, it may be expected to exhibit eight normal modes of oscillation. Nayar and Anna Mani have made a detailed study of the vibration Raman spectrum of diamond. Identifying their observed

values with the theoretically possible normal modes, we get the following force constants :

$$K_1 = 3.14 \times 10^5 ; K_2 = 0.197 \times 10^5 ; K_3 = 0.39 \times 10^5 \text{ dynes/cm.}$$

X-ray determinations give us 3.56 A.U. for d . Using these values, we can calculate the elastic constants and obtain

$$C_{11} = 95.0 ; C_{12} = 40.0 ; C_{44} = 44.0 \times 10^{11} \text{ dynes/cm}^2.$$

These compare very well with the observed values

$$C_{11} = 95.0 ; C_{12} = 39.0 ; C_{44} = 43.0 \times 10^{11} \text{ dynes/cm}^2.$$

ELASTIC CONSTANTS OF MIXED CRYSTALS

A study of mixed crystals is likely to furnish interesting results. Information regarding their elastic behaviour can be obtained by applying the new method. Seven different specimens of garnets obtained from different sources in India have been studied by Ramachandra Rao in the author's laboratory. Garnets were chosen by him because they are available in large quantities as well formed single crystals. Further they belong to the cubic system and hence simplest to work with. His results are given below in Table IV.

TABLE IV
ELASTIC CONSTANTS OF GARNETS

<i>Specimen No.</i>	1	2	3	4	5	6	7
<i>Property</i>							
Density	3.759	3.673	3.630	3.670	3.750	4.130	4.320
C_{11}	19.7	19.2	21.0	22.2	22.6	27.3	32.7
C_{12}	9.0	9.9	10.3	10.4	12.6	15.7	12.4
C_{44}	5.7	5.9	6.7	7.0	6.2	6.8	8.9
Bulk Modulus	12.6	13.0	13.9	14.3	16.0	16.2	19.0
Ferrous iron (in percentage)	21.8	22.7	23.6	23.0	26.2	28.7	33.5

It is seen that the individual elastic constants do not vary regularly with composition, but the bulk modulus varies linearly with the ferrous content, which in almost all the cases happens to be the total iron content. Studies on other mixed crystals are in progress and we hope to get some interesting data.

CONCLUSION

The new method described here for determining the elastic constants of materials in the form of small plates opens up an experimental field of investigation which is much wider in scope than that hitherto possible. Practically all the solids, crystalline or otherwise, can be studied. It is hoped that further improvements may be effected so as to enable the extension of such studies to varying physical conditions. Experimental data thus collected, in conjunction with a knowledge of the force fields derived from spectroscopic studies, are likely to throw much light on the nature of the solid state.

SECTION OF CHEMISTRY

PRESIDENT : DR. B. C. GUHA, PH.D., D.Sc., F.N.I.

FOOD

(Delivered on 3 January, 1946)

I am deeply sensible of the honour you have done me by asking me to preside over the Chemistry Section of the Indian Science Congress this year. I am conscious that there are far more qualified individuals who could have discharged the presidential responsibility with much greater competence. I have, however, humbly accepted this office taking it as a mark of recognition of the importance of biochemistry, food and nutrition in the world of science.

I hope I shall be pardoned if I say that biochemistry has been a Cinderella of the sciences in India and in spite of the fact that the science of food and nutrition is probably the most important science concerned with the well-being of the people, its recognition so far has been relatively very meagre. Long before this war, all these subjects began to be actively pursued in Europe and America and the war brought into bold relief the importance of these sciences and of their application throughout the world. That food is the first essential of all living things is a truism. But the extent to which food, qualitatively and quantitatively inadequate, has affected the health of vast masses of the population began to be realized barely 15 years ago. Food and nutrition surveys in Britain and America revealed that about half the people of these rich countries were not at an optimum level of nutrition according to modern standards. Although precise figures are not available for India, it would not be a wild guess to say that probably 80 to 90 per cent of her people are either under-nourished or mal-nourished or both. That we are perpetually walking on the brink of the precipice was shown when we fell over the precipice in the tragic year of 1943. A social, political and economic order, which has to watch on when millions die of starvation, has obviously long outlived its usefulness and become a clog in the wheel of progress.

In India before the war scientific as well as public recognition of the basic importance of food was exceedingly inadequate. In the vast majority of our universities and scientific institutions, including medical, there is still no full-fledged department of biochemistry and the volume of work on food and nutrition produced in India is relatively very small compared with that in America, Russia and England. I would make here a special appeal for the organisation of departments for these studies in all the universities and medical institutions in India and would also urge the creation of special institutions devoted to particular subjects like biochemistry, nutrition and food-technology.

In view of the importance of the science of food I make no apology for taking this subject for a brief discussion today.

The development of science has to be envisaged in both pure and applied aspects. To pursue exclusively the applied side ignoring fundamental scientific studies would be, as J. J. Thomson once said, like ploughing a field and forgetting to sow the seeds. It is true that in this country even what we know about the science of food and nutrition has not been applied to any appreciable degree and this is a matter which requires the first attention of the Government and the public. But it is also true that progress on the applied side, if it is to be maintained on right lines, requires that the path should be continuously illuminated by the light of pure research. As an example it may be pointed out that in the last century we were thinking mainly of the major food constituents—proteins, fats and carbohydrates—in connection with human nutrition, now as a result of the discovery of vitamins the applied aspects of nutrition have been to a large extent revolutionized. In the last two or three decades the recognition, identification and production of vitamins have proceeded at an unprecedented speed and these discoveries have proved to be of inestimable value during the war-time conditions of food supply. Under Lend-Lease enormous quantities of synthetic ascorbic acid have been sent by America to other countries of the world where the sources of vitamin C were limited. The production of synthetic vitamins of the B group has led to the fortification of 80 to 90 per cent. of the total bread produced in America. I shall refer to this subject later again. I am pointing this out in order to indicate that the fountain of fundamental researches must be maintained if the field of applied nutrition is to be kept continuously irrigated.

FUNDAMENTAL STUDIES

During recent years quite a large number of vitamins of the B-group have been recognised and synthesised. We have now synthetic thiamin, riboflavin, niacin, pyridoxin, pantothenic acid, biotin and *p*-aminobenzoic acid. Folic acid is considered a new vitamin which may be identical with the grass factor, which was indicated by the writer in a paper in 1931. Vitamins A and A₂ and different D vitamins have been recognized. Vitamin C has been synthesised. A new vitamin P has been recognized. Vitamin E has been synthesised. The vitamin-like nature of certain unsaturated fatty acids is now largely accepted. There is some evidence for the existence of new factors, vitamins B₁₀ and B₁₁ (Elvehjem). There is also evidence of growth-promoting activity for chicks in fish-pressed water which is probably not accounted for by known vitamins. Thus the discovery of still more new vitamins is in the offing.

Our progress in the knowledge of the fundamental scientific nature of vitamins and particularly their synthesis, which has made some of them readily available, have greatly stimulated our understanding of their mode of action. We are now aware that a number of the B vitamins are concerned in the enzyme systems responsible for biological oxidation. The stages at which the vitamins participate in the metabolic process are a little better understood than before in one or two cases. The results obtained by S. Banerjee indicate that vitamin C may be connected with insulin secretion which would probably be the first indication of the relation between a vitamin and a hormone. The observations of S. Roy in our laboratory indicate that the bio-synthesis of vitamin C in rats involves thiamin and probably also riboflavin. Some of the B vitamins and vitamin C would thus appear to be biochemically related. That the path of the bio-synthesis of vitamin C, which is stimulated under the influence of narcotics as was shown by King and his co-workers, constitutes probably a diversion of the normal path of

carbohydrate metabolism, is indicated by the work of B. Ghosh, S. Roy and S. K. Roy. That vitamin D is concerned in calcium and phosphorus metabolism is well known, but the details of the process are not yet completely clarified. The stimulating effect of vitamin E on the utilisation of vitamin A has recently been shown by Harris at Rochester, N. Y. The lack of vitamin E has been shown not only to produce sterility but also to produce muscular dystrophy. It has been shown that partial deficiency in vitamin E is more widespread than has been suspected. Work has been carried out in Prof. Elvehjem's laboratory on the synthesis of certain vitamins of the B group by intestinal micro-organisms. It would appear that this might be an appreciable source of these vitamins to man which would supplement the ingested vitamins. This again is worthy of further investigation. Substances which are called anti-vitamins have been recognised and it is interesting to see how desthiobiotin is an antagonist to biotin. Similarly, riboflavin is antagonised by isoriboflavin which contains two methyl groups in 5, 6 positions instead of 6, 7 positions as in riboflavin. Thiamin is antagonised by pyriethiamin and nicotinic acid by β -acetyl pyridine. The explanation suggested for this highly interesting phenomenon is that the anti-vitamins compete with the vitamins in relation to the enzyme systems involved in cellular respiration. However, the claim by Woolley that glucoscorbic acid is an antivitamin appears to have been disproved by S. Banerjee. How slight changes in the structure of the vitamins convert them into anti-vitamins is indeed a field for interesting investigation. The relation of certain vitamins like *p*-aminobenzoic acid to bacterial enzyme systems and the competition of sulphonamide drugs with it, which appears to be largely responsible for the anti-bacterial action of sulphonamide drugs, has indicated new lines of fruitful study. The above illustrations indicate far too briefly the new lines of fundamental vitamin studies, which besides extending our bounds of knowledge, will have important repercussions in the field of applied nutrition. It is important to recall that even 20 years back we were completely ignorant of the mode of the biochemical action of vitamins and now we may at least claim to have the glimmering of light on that highly complex question. While I have the feeling that further light will reveal still greater complexity of the problem, yet it is no mean satisfaction to reveal a complexity instead of being ignorant of it. Doubtless, with the present tempo of progress, complexity will both be revealed and unravelled in which I would urge Indian workers to take part. As I have said, the implications of these researches in the applied field are also very far-reaching.

Striking developments have taken place also in other directions. The phenomenon of transmethylation in the tissues and the importance of labile methyl groups in certain dietary constituents have been recognised by du Vigneaud and co-workers. Light has been thrown on enzyme systems concerned in the metabolism of amino-acids by N. Das, O. Warburg, F. Koogl and others. The phenomenon of transamination has been discovered largely as a result of the work of Braunnstein. The dynamics of amino-acid metabolism have been studied by the use of heavy nitrogen and heavy hydrogen for labelling the molecules (du Vigneaud, Schoonheimer). The theory of a dynamic equilibrium between tissue and plasma protein seems now to be well established by the use of the same isotope tracer technique (Whipple). Researches have been carried out on the metabolism of fats in a similar way by the use of deuterium (R. S. Harris). Similarly, by the use of radioactive isotopes, calcium, phosphorus and iron metabolism has been sought to be more closely studied and mineral metabolism generally has received a good deal of attention including that of trace elements. With radioactive iron

the very interesting and useful observation has been made that while human beings absorb ferrous iron preferentially, a marked preference of ferrous over ferric iron was not observed in the case of dogs, indicating a definite species variation in biological reaction. Carbohydrate metabolism still continues to be a subject for fruitful studies because of its varied connection with proteins, fats, vitamins, hormones and enzymes.

Work has continued to be carried out on the important question of the human requirements of different nutritive factors, including vitamins. Mitchell makes the generalisation "that the body's primary need for nutrient is for food energy and that its need for most of the specific essential nutrients is in proportion to the amount of food energy consumed". The minimum requirement of protein appears to be also related to basal metabolism (Terraine-Smuts relationship). However, our knowledge about the requirements of nutritive factors is still incomplete and much further work needs to be done on this subject as recent researches indicate that the requirements of various factors are influenced by the nature and quantity of other constituents of the diets. A striking example is the sparing action of fat on thiamin as was observed by Lepkovsky and the differential sparing action of different fats and oils as was observed by the writer many years ago. The deleterious effect of feeding an excess of certain vitamins has also been established including the toxic effect of a large consumption of vitamin A. The poisoning of Arctic explorers by the consumption of the liver of polar bears has been traced to its large content of vitamin A.

Interesting observations have recently been made on the alteration of amino-acid metabolism in moulds and also of their ability to synthesise vitamins by exposure to x-rays. It would appear that the use of radiations of different kinds would in future years throw more light on biochemical transformations in protoplasm. This should be a line for fruitful study. May I hope that some day we shall be able to interpret living phenomena in terms of energy levels and the newer developments in atomic physics.

A passing reference may also be made to the medical implications of some recent nutritional researches. The use of certain vitamins for the treatment of various deficiency diseases is quite well-known. The new vitamin folic acid has been claimed to be effective in the treatment of pernicious anaemia. Riboflavin has recently been recommended for the treatment of the condition of perleche of which, however, full confirmation is necessary. The therapeutic effect of glutamic acid on the treatment of the petit mal type of epilepsy has been claimed, while it has been found quite ineffective in the treatment of grand mal. Highly interesting have been the observations of Zimmerman and Ross who claim that incorporation of *l*-glutamic acid in the diet increases the learning ability of rats. It reduces the time required to learn a maze to a 3rd or a 4th of the time needed by the control animals. Glycine as a contrast had no effect. These results are curious considering that the diet normally consumed contains glutamic acid in the protein. However, these observations would be interesting to our young learners, and if glutamic acid can help them before an examination, it will be a tribute to biochemistry!

FOOD TECHNOLOGY

The need of pursuing fundamental researches on biochemistry and nutrition has been indicated above. Another line in which our country is far too deficient is the applied science of food technology including the processing of foodstuffs in order to preserve or enrich them. The production of food

in our country is not adequate if we are to plan nutrition for the people according to the standard prescribed by the National Research Council of America or even at a lower standard. Secondly, a considerable part of our food-stuffs perishes annually because of rodents and insects which abound in tropical countries. It has been roughly estimated that about three million tons of food-grains alone are lost in India owing to damage by rodents, insects and moisture. If we consider all food-stuffs in this country, including such perishable materials as fish, milk, meat, vegetables etc., the extent of our loss may be guessed. There is not much value in a "Grow More Food Campaign" if a considerable part of the food produced perishes for lack of development of food-technology in this country.

Regarding grains the main question is that of drying the grains to a low moisture content, preferably of the order of 8% which makes the grains resistant to insects and moulds. This drying is normally carried out in this country in the sun, which, while it is rather inexpensive, has got its disadvantages because of the fickleness of weather, dust etc. In the West grain-dryers are extensively used for rapid and uniform reduction of the moisture content of grain. Once dried, the grain has to be stored in proper bins or warehouses so that re-absorption of moisture may be as little as possible. It is obviously no use drying the grain if it is stored later in a condition facilitating moisture re-absorption. Fumigation is resorted to frequently and a number of fumigants have been used, among them more particularly ethylene oxide and ethylene dichloride in America. Various inert dusts have been used also to prevent insect infestations. In recent months experiments have been carried out with D.D.T. and 666 with good results. All these researches have to be actively pursued as they have a tremendous bearing on the problem of the preservation of the food grains in this country. The deterioration of food-grains, particularly during the war years, has been most distressing, and enormous quantities of such food grains have been thereby lost to a people already suffering from want of food. Prof. V. Subrahmanyam has made commendable efforts to recondition deteriorated food-grains.

In Britain in course of the war a national flour was introduced which was 85% extraction flour so that more of the B vitamins and iron might be retained. Some time back the extraction was reduced to 80 per cent. To this flour was added about 0.16% of calcium carbonate so as to fortify the flour with calcium in order to counteract the anti-calcifying effect of phytic acid contained in the flour.

In the U.S.A. about 80 to 90 per cent of the bread is being enriched with thiamin, riboflavin, nicotinic acid and iron and the extra cost, as Dr. R. R. Williams informed me, came to barely -/8/- annas per head per year.

A process of "converting" rice has been developed by Huzenlaub by which the vitamins are driven towards the interior of the grains so that during milling and polishing the rice grain does not lose much of its vitamin B factors. The method makes the rice harder and, therefore, more resistant to insects. There is also less loss due to powdering during the milling process. However, it is not yet clear whether this method gives an outstanding advantage over the parboiling process which also helps the vitamins to be retained in the rice grain during the milling process and of which Huzenlaub's process is an improved and mechanised modification.

A method has been developed for fortifying rice with the B vitamins and then coating the rice grain in such a manner that during the washing of the rice the added vitamins are not leached away. This fortified rice which is called a premix may then be mixed with a very large bulk of unfortified

rice in order to give a rice of high average vitamin content. All these methods are worthy of consideration in connection with the development of food technology in this country so that our people may be more adequately fed quantitatively and qualitatively.

It may be stated in passing that the Ministry of Food specialists have found zinc phosphide to be the most effective agent for destroying rodents.

Among the different methods of food technology, canning, dehydration, freezing, etc., the freezing technique has made the most headway in America in recent years. It is high time that in India refrigeration were extensively established for preserving food-stuffs which undergo spoilage by attacks of insects, moulds and fungi as well as by autolysis at a higher rate in a tropical climate than in the temperate climate of the West. The Birdseye quick-freeze technique has been developed greatly in the United States. The principle of the method consists in cooling down the food-stuffs very quickly to a temperature of the order of -30°F . and then storing the frozen product somewhat below 0°F . until the time of consumption. In actual practice the factories are located where the raw materials are available. The factories quick-freeze the fresh food-stuffs and then put them in warehouses maintained at a temperature of 0°F . to -18°F . From there they are sent in insulated transport, which is cooled inside by some refrigerant, and brought to the consumption centre where they are again stored in warehouses at temperatures of 0°F or below. The retailers obtain their daily supply from these warehouses which they keep in their ordinary refrigerators and sell during the day. The development of refrigeration process for food-stuffs, however, requires a fairly extensive organization. Once this organization is achieved, the process is simple. The advantage of quick-freezing is that it is the only process whereby the food-stuffs are retained in a condition which is practically indistinguishable in taste and flavour from the fresh food-stuffs. We have tasted haddock which was preserved for three years in such a manner that it was not possible to tell it from a fresh haddock when cooked and tasted. On the other hand refrigeration of food-stuffs does not save space as dehydration does. But canning as an alternative procedure takes even more space. There are several methods by which this quick-freezing technique has been applied.

(1) *The Birdseye Process :*

In this process the Birdseye multiplate freezer is used which consists of a number of super-imposed hollow aluminium plates through which the refrigerant is running. These plates are hydraulically operated so that the distance between them can be adjusted. The food-stuffs are wrapped in waxed paper, put in a card-board carton and are placed between two hollow plates and then the plates are adjusted so that they are brought just in touch with the carton. Freezing takes less than two hours after which the food package can be removed and stored in the cold warehouse. In recent years mobile units of this type have been built which, complete with everything, can be moved from place to place if production requirements make that necessary. This is a process which is extensively used in many fish factories in America. For freezing vegetables it is usual to blanch them before quick-freezing to destroy the enzymes.

(2) *Blast Freezer :*

In this system a cold blast of air cools down the food-stuffs. The blast is allowed to go through a chamber containing horizontal coils with fins to facilitate cooling. The refrigerant is allowed to flow through the coils and the food-stuffs in trays are placed on the coils. Alternatively the food-

stuffs in trays can be placed on trucks which are moved into a tunnel through which a cold blast is passed.

(3) *Finnegan Tubes* :

These tubes are used particularly for the freezing of fruit juices like orange juice. In America ordinarily orange juice is canned or bottled with or without previous concentration. But during recent years the method of freezing by Finnegan Tubes has been adopted. The cans containing the deaerated orange juice and closed under vacuum are placed in inclined tubes through which refrigerated alcohol at approximately -35°F . flows at a high velocity. As the cans pass through the Finnegan Tubes under gravity, they come in contact with the cold alcohol and the contents of the can freeze very quickly. The frozen juice is considerably more akin to fresh juice in taste and flavour on thawing than the ordinary canned or bottled orange juice of commerce.

There are many variations of the above methods. The workers of the Massachusetts Institute of Technology had kept completely cooked meals in a frozen condition at -10°F . for a pretty long time. This could be warmed up at the time of serving and had not deteriorated appreciably in taste and flavour.

It should be stated that quick-freezing has been found to be a first class method for preserving fish and vegetables. Many fruits also can be quick-frozen, particularly, straw-berries, goose-berries, cherries etc. But many other fruits would not keep well in a quick-frozen condition. For such fruits gas storage, that is to say, storage in an atmosphere containing a certain ratio of carbon dioxide to air has been found to be very effective. Under these conditions the respiration of the fruits is retarded but not completely stopped. Gas-stored fruits are maintained at a temperature at or slightly above the freezing temperature. Apples and pears behave well to gas storage and it is probable that mangoes also would do well, but the exact conditions would have to be worked out.

Canning is an established process and need not be referred to in detail. In recent years they have developed many automatic machineries for the canning industry including continuous pressure cookers and pressure coolers.

Dehydration has particularly come into prominence during the war as it is meant both for the preservation of food-stuffs and for reducing their volume and weight. Dehydration of fish, for instance, would reduce the actual consumable part of the fish to only about 1/20th of its original weight. This means considerable saving in space which is so important in war-time. Dehydration of vegetables has been quite extensively carried out during the present war in this country and also elsewhere. The method consists in putting the washed, sliced and blanched (usually in sulphite solution) vegetables on trays which are placed in trucks, which are led through tunnels under a blast of hot air. There are tunnel systems of various designs in different countries, sometimes using a single counter-current air blast, some times a parallel flow air blast and often a combination of the two. The last is the most effective. There are methods for compressing some types of dehydrated vegetables whereby the space occupied can be further reduced. Dehydrated food-stuffs are preferably packed in tins in an atmosphere of nitrogen or carbon dioxide. The storage quality of dehydrated vegetables is obviously of great importance and quite extensive studies have been carried out on the changes which occur in dehydrated vegetables during storage. If there is air there is deterioration. There is also a deterioration from the Maillard reaction between reducing sugars and amino-acids. The browning

thus caused is non-enzymatic. It is usual in dehydration practice to blanch the vegetable carefully so that the enzymes which might cause subsequent enzymatic deterioration are pretty effectively destroyed. Pre-cooked dehydrated vegetables have also been prepared. They reconstitute in water considerably more quickly than ordinary dehydrated vegetables.

Dehydration of fruits is an established industry in the U.S.A. In this country in the N.W.F.P. during the present war, fruits like peaches, apricots, plums, pears, etc. have been sulphured, sun-dried, washed with water and sulphured again. They have been subsequently dehydrated in a tunnel dryer. Straight dehydration of the fruits has also been practised recently both in India and in the U.S.A. in which the fresh fruits are blanched, sulphured and dried in a tunnel dryer like vegetables. This gives a good product of fairly uniform quality if the conditions of processing are carefully observed. Experiments are now in progress in the N. W. F. P. to see if dipping in metabisulphite solution may replace sulphuring.

Temperature has an important effect on the rate of deterioration during storage of dehydrated vegetables and fruits. Therefore, it is desirable that all dehydrated food-stuffs should be kept in a cool place if a fairly long storage life is desired. Dried fruits, in fact, deteriorate 2.5 times faster for every 10°F. rise in temperature.

Meat has been dehydrated during this war in India, Australia and Argentina. The method of producing sliced dehydrated goat's meat in India is more or less similar to that of dehydrating vegetables. Pre-cooked minced meat has been produced in Argentina and Australia.

Precooked minced fish has also been dehydrated on a pilot plant scale which gives a quite palatable product in the form of fried fish cakes. I wonder whether the shark flesh, which is available in large quantities in the shark liver oil industry in India, may not be dehydrated to produce a good protein food. Shark flesh contains a little urea which unfortunately gives a slight after-taste of ammonia, but possibly the urea may be leached out from the shark flesh before dehydration.

New methods of dehydration have been tried. Fruits, for instance, have been dehydrated in America under vacuum at an average temperature of 120°F. to give fairly good products. This has the advantage over tunnel drying in that it gives a quicker turnover and also there is less heat damage to the fruits.

Another method is to dry food-stuffs in the frozen condition as plasma is dried. This has not yet come into industrial practice because the economics of the process so far are against it. But eggs, for instance, which are normally spray-dried give a first-class product if they are dried under high vacuum in a frozen condition. The flavour is almost like that of fresh eggs, which is hardly the case with spray-dried egg powder. Attempts are being made to freeze-dry milk also which is normally spray-dried or roller-dried. Freeze-dried milk is considerably better in flavour and nutritive quality than the other forms of dried milk powder. This method of drying seems to be a promising line of development particularly for milk and eggs. I have seen freeze-dried straw-berries, peas etc., which are also good but so far the cost of freeze-dried vegetables has been considered to be too great. It may not, however, always be so.

Another new method of drying has been by heating in oil under vacuum. Potatoes, fish, etc. can be dried quickly under vacuum if they are heated in oil. This is a method also capable of development in India. The product,

however, contains always a certain quantity of oil, which probably would not be unacceptable for fish and vegetables.

Radio-frequency energy has also been used for dehydration but so far not with industrial success.

For drying of fish, dry-salting is an important process which is fairly extensively practised in Europe and America and it is probable that our indigenous method of fish drying may be considerably improved in the light of the experience of the dry-salting industry. Among all the processes of preservation of fish, dry-salting would be the cheapest. But it would not obviously give as good a product as other methods of preservation, particularly refrigeration.

Smoking of fish is also a method of preservation of fish but smoked fish will have to be popularised in India if this method has to be developed.

Dehydration work has gone on so far in America that one could get a complete meal from dehydrated food-stuffs including dehydrated icecream and dehydrated chutneys.

While considering alternative processes of preservation, canning, refrigeration, dehydration, etc., it is important to remember that they should not be regarded to be so much competitive as co-operative as there are circumstances under which one or other process would be suitable and some times the same factory may carry out all the three processes even with the same food-stuffs. The development of food-technology in this country on right lines would require considerable planning.

Under food-technology we may also refer to the production of vitamins and food yeast in this country. Enormous quantities of all the important vitamins are now being produced particularly in the U.S.A. and it is of great importance that for a country like India with a vast mal-nourished population we should produce them also in required quantities. The synthetic vitamin industry, however, is bound up with a basic chemical industry and solvents industry. But it is time that the development of this industry is considered in detail in connection with the development of related industries so that the production might be economic.

The method of production of food yeast has been developed by Dr. Thaysen and this method has been found to give a good yield of food yeast of high nutritive value to the extent of 25-30% of the molasses used. Since over four hundred thousand tons of cane molasses are produced in India annually the production of food yeast from a part of this molasses is worthy of consideration.

In connection with food-processing industries it should be mentioned that the development of this industry not only preserves large quantities of perishable food-stuffs but it also helps to take off the seasonal gluts, thus making the price even throughout the year. At present due to seasonal gluts in, let us say, mangoes, liches or hilsa fish, the prices are often uneconomic to the producer while considerable quantities perish because they cannot be sufficiently quickly transported to consumption centres. At the same time, in off seasons these food-stuffs are either unavailable or available at a very high price. An even price throughout the year would be good both to the consumers and the producers.

BY-PRODUCTS OF CERTAIN FOOD-PROCESSING INDUSTRIES

As indicated above the development of food industries helps to conserve food-stuffs and maintain a more or less even price throughout the year.

Apart from these, the food industry provides by-products of considerable value which are lost when unprocessed foods are consumed in individual homes. For instance, in the canning of orange juice in America a number of by-products are obtained. The oranges are processed by washing, halving, pressing out the juice mechanically which is deaerated under vacuum, flash-pasteurised at 196°F. and then bottled or canned with or without concentration under reduced pressure. From this industry the peelings of the oranges are obtained which are pressed to give the orange oil which is an important flavouring agent. The pulp is preserved in barrels with preservatives for preparing squashes. The residue of the orange peelings is dehydrated into a valuable stock-feed by drying it in a rotary dryer. There is a proposal to mix it with wheat flour also for human consumption. Attempts are also being made to utilise the aqueous portion separated from the orange oil. This is being concentrated by a triple effect evaporator to a molasses-like substance which is used as a mixture in stock-feed. There is also a proposal to ferment it to alcohol or to grow yeast for either human consumption or for cattle feed. Pectin is also being produced from the peelings. This is a well-known product of considerable value.

It will be observed from the above that in the orange-processing industry not only the orange juice is made available to the consumers in a readily consumable condition but it also provides a variety of important by-products which would have been lost if the oranges were consumed in individual homes.

It may be stated in passing that orange juice has been sought to be concentrated by freezing out the water as ice and centrifuging (Kraus-Linde process). The process does not seem, however, to have yet been used industrially in America. Beer has also been sought to be concentrated similarly.

Another processing industry in which a number of useful by-products can be obtained is that of fish. In such an industry the fish is usually filleted and then used for canning, refrigeration, etc. The scales are often converted into glue. The fish offal including rotten fish is dried in a rotary dryer to give a good protein meal for stock and poultry feed. Before drying, the offal is treated with live-steam in a horizontal rotary cylinder. The material is squeezed in an expeller which expels all the fat-water mixture. This is then separated. The fat is used and the water solution is evaporated in vacuum to give a paste rich in "vitamin B" which is a good poultry feed. The livers, if of right quality, are processed for the production of liver oil. Shark liver oil is subjected to molecular distillation in America to give a very potent vitamin A concentrate.

It will be seen from the above that a fish-processing industry not only provides fish to the consumers in a readily edible condition, which entails practically no drudgery in the home, but it also provides a number of valuable by-products which are lost when whole fish is bought and prepared in individual house-holds.

Similar remarks apply to meat and vegetable processing industries.

FOOD AND NUTRITION POLICY

Researches on food and nutrition must consistently be applied to the practical problem of improving the nutritional level of the people. All scientific work must have as its goal the increase of the sum of human happiness. Our country is pre-eminently one where hardly a fraction of accumulated knowledge has been applied in various fields of national welfare. Since nutrition is the first and basic element for life and health it should have the highest priority for consideration. It may be interesting in this connection

to recall the experience of a British medical officer who found, curiously, that on removing certain working-class families from slums to better hygienic quarters the health of their children deteriorated. This apparent anomaly was traced to the fact that these families had to spend a larger proportion of their income on the rent of their apartments than they had done before and consequently the money available for food was less. The deficiency in food was dramatically felt. As Gowland Hopkins once remarked, among all the environmental factors which determine health and vigour, nutrition was the most important. The aim of modern civilization should be to achieve the highest standard of health of which the individual is capable within the limits set by heredity.

The scientific principles of nutrition have been applied with a great measure of success during the recent war in some of the Western countries. In the U.K. rationing has actually improved the nutritional level of the poorer sections of the population. In fact, it has been stated that the average stature of the British boy or girl of to day is significantly higher than before the war. This is attributed to the fact that the whole organisation for nutrition in England has been run under effective scientific guidance. At the beginning of the War, the scientific organisation of the Ministry of Food carried out an estimate of the food production in calories, protein, etc. in normal times and compared it with the nutritional requirements of the people of Britain in respect of all the nutritive factors. The next question was to meet the deficit from increased home production and from imports. It was decided to stimulate production of energy-yielding food-stuffs like wheat and potatoes in Great Britain in order to save shipping space and to import largely, concentrated and protective foods like dried egg powder, milk powder, orange juice etc. Milk was first given to children and expectant and nursing mothers, who formed the priority groups, and then, if available, to adults. Milk was given free to tens of thousands of children and at cheap rates to other children and expectant and nursing mothers. A national flour was introduced, as has been mentioned earlier, which was richer in B vitamins, iron and calcium than the pre-war flour. Communal feeding was introduced (as had been done long ago in the Soviet Union) through factory canteens and through the so-called British Restaurants which catered for the public. Cheap meals, nutritionally balanced under scientific guidance, were provided in these communal feeding centres. Special capsules containing vitamins A and D were provided for expectant and nursing mothers. Rationing for different age groups was based on nutritional considerations and provided optimum nutrition according to modern accepted nutritional standards. Constant checks were kept on the nutritional status of different groups of the population produced by the rationing system and other food and nutritional measures. Periodic reports of this status regarding representative groups of the British population were regularly received by the Ministry of Food which examined these reports and kept their administrative measures in constant review in the light of these. A group of workers was appointed at the Oxford University to constantly look after the nutritional status of the people from the clinical point of view as affected by current rationing and other food measures.

The way that the Ministry of Food has handled food and nutrition problems of the U. K. during difficult times by taking and implementing scientific advice all along is an example to many other countries. All these scientific nutritional measures, however, could not have achieved much had not the Government sought constantly to grow and import all the food materials that were needed. The production of food in the U.K. increased by

over 50% in certain commodities. The policy which was principally responsible for both the success of the "Grow More Food Campaign" and the stabilisation of the prices of staple food-stuffs was the policy of direct subsidy to the food-growers including producers of wheat, potatoes, meat, milk etc. In one year alone over two hundred crores of rupees have been given in direct subsidy to the food growers. The result has been that more food has been produced and the prices of none of the staple food-stuffs have risen higher than 25% above the pre-war level. Potatoes were sold at London at 1½d. per lb. This could not have been achieved by price control decrees alone. Similarly constant attention was paid to the importation of concentrated food and protein food. The whole food position of the U.K. was under constant review and the Govt. made every effort to see that all the food required for the entire population, both civilian and army, on nutritional considerations was actually available to the people. The results have shown that the Govt. by its efforts succeeded in this objective.

The nutrition policy which has achieved so much success in the U.K. can be followed with suitable modifications in this country. The first task is to estimate the requirements of food by the people of India in the light of optimum nutritional considerations. In an article published in March, 1944 (*Science and Culture*, Vol. IX, p.375) I had given the following requirements for an adult which may be considered nearly optimum. The relative proportions of different ingredients of this diet may of course be varied within certain limits and also some variations in the nature of the cereals according to local supplies may be permitted :

Unmilled or lightly milled rice	..	..	10 oz.
Whole wheat	..	..	6 oz.
Pulses	..	..	4 oz.
Sugar	..	..	2 oz.
Milk and milk products	..	..	10 oz.
Fish and meat (or extra milk products for vegetarians)	..	..	4 oz.
Non-leafy vegetables	..	..	5 oz.
Green leafy vegetables	..	..	5 oz.
Fats and oils	..	..	2 oz.
Fruits	..	..	3 oz.
Eggs	..	..	one or two

Such a diet would supply roughly the following nutritive elements :

Carbohydrate	..	..	470 g.
Fat	..	..	75 g.
Protein	..	..	96 g.
Calcium	..	..	1.1 g.
Phosphorus	..	..	2 g.
Iron	..	..	34 mg.
Carotene	..	..	4 mg.
Vitamin A	..	..	1.6 mg.
Thiamin	..	..	2 mg.
Riboflavin	..	..	1 mg.
Vitamin C	..	..	90 mg.
Calories	..	..	2,780

This would entail an annual production in India of the following :

Cereal grains (mostly rice and wheat)	..	65	million tons
Pulses	..	16	" "
Sugar and "Gur"	..	8	million tons
Milk	..	40	" "
Fish and meat	..	16	" "
Nonleafy vegetables	..	20	" "
Green leafy vegetables	..	20	" "
Edible oils	..	7½	" "
Fruits	..	12½	" "
Eggs	..	15	billion

Sufficiently accurate statistics are not available about the present production of many of these food-stuffs. But it is clear that increased production will be necessary in each of these items if these nutritional requirements have to be met. It should be stated that the diet indicated above does not in several respects come up to the standards laid down by the National Research Council of America, which however may be a little too high.

Regarding vitamins, owing to the great developments in their manufacture, it is now possible to provide synthetic or concentrated vitamins to large masses of the population at a reasonable price. The targets of the annual production of vitamins in India may be tentatively indicated as below :

Carotene	..	300	tons
Vitamin A (concentrate)	..	150	" "
Riboflavin	..	300	" "
Thiamin	..	300	" "
Nicotinic acid	..	3,000	" "
Vitamin C	..	7,500	" "
Calciferol	..	1.5	" "

Indian diets are also usually low in calcium and the following targets may be given for the annual production of assimilable calcium and phosphorus compounds calculated as calcium and phosphorus, 1.2 lac tons and 2 lac tons respectively.

The above would indicate the lines on which development should take place leaving room for readjustment of figures of production.

The provision of vitamins and minerals in tablets is no longer a subject for humorous comment but is already being practised in America and appears to be a desirable development from the standpoint of the improvement of the general level of nutrition. Calories and proteins are required in fairly large amounts but vitamins and minerals are required in relatively small amounts. The last two are also not often present in adequate quantities in the food we consume. It is possible to provide the vitamins and minerals in the form of tablets or capsules. If the major portion of the requirements of these food elements can be met from the manufactured materials, leaving the rest to be provided by the natural diet, it seems entirely logical to adopt this system instead of leaving it to chance that the ordinary food would provide adequate quantities of these nutritive elements. This may entail a slight change in our food habits, but food habits have changed during centuries. It should, however, be stated that in spite of the synthetic vitamins natural food-stuffs are still needed to provide probably still unknown vitamins. But there is no reason why we should not take the more important

synthetic vitamins daily thereby ensuring an adequate supply of these particular substances. The chief aim should, however, always be to provide adequate natural food to all people.

The problem of food before India and also other oriental countries is colossal. How ill-fed Asia and Africa are compared with other continents would be indicated from the following table taken from Marrack, which gives the distribution of world's food supplies among the different continents :

<i>Food supplies</i> \ <i>Continents</i>	<i>Europe</i>	<i>Asia</i>	<i>North America</i>	<i>Latin America</i>	<i>Africa</i>	<i>Oceania</i>
Cereals & other food-stuffs	41.2	24.6	24.4	5.8	2.5	1.6
Meat	45.7	5.6	29.7	11.9	3.4	3.7
<i>Per cent of world's population</i>	25.9	52.5	6.5	5.7	6.7	5.5

It will be noticed that the consumption of practically all food-stuffs in Asia and Africa is frightfully small compared with the consumption in Europe and America although Asia and Africa are far more populated than the other continents. This is indeed a shocking situation.

Science and technology have placed plenty within the reach of all the people of the world. The fact that hundreds of millions of people throughout the world are on a low subsistence level is a slur on our civilization which we can remove only by establishing a social and political order which will ensure that it is not the income of the individual but his physiological needs that will determine the food that he eats. Until this social change is brought about, humanity will continue to wander in the wilderness and our long night will never dawn.

SECTION OF GEOLOGY AND GEOGRAPHY

PRESIDENT : H. Crookshank D.Sc.

WAR AND THE INDIAN MINERAL INDUSTRY

(*Delivered on 3 January, 1946*)

It has been the custom for the President of the Section of Geology and Geography at the Indian Science Congress to discuss recent developments of Indian Geology. It is with regret that I am unable to add anything on these lines to what has already been published. My excuse for this must be that war has forced Indian Geologists to devote practically their entire energies to matters of immediate economic importance, and to neglect that theoretical side of their work on which reliable economic results must always be based.

I have chosen instead for my subject "War and the Indian Mineral Industry". Having fought in two world wars and seen something of the Indian mineral industry during the last 25 years, I feel that I am entitled to opinions on such a subject, even if they are not generally accepted.

The minerals vital for the industry and defence of any country are coal, oil, and iron-ores. They are costly to transport, and no country which has not at least fairly large supplies of them can hope to have a balanced industry on which its defence can rest in time of war. All other metals and minerals are needed in industry in relatively small amounts and can be imported from countries with surpluses for sale comparatively easily. India has a great surplus of excellent iron-ore, coal supplies which if carefully used should suffice for her industry for a considerable period but, so far as is now known, inadequate oil supplies. As no country with the possible exception of the U.S.A. is adequately endowed with all these three natural assets, I think it can reasonably be claimed that India is fairly well off as regards the primary raw materials of defence.

As regards the numerous metals and ores needed by a highly technical modern defence industry, India is relatively poorly placed, but she holds large surplus supplies of a few of the more important war minerals which can be exchanged both in peace and war for the raw materials which she lacks. Among the essential minerals and metals in which she is deficient at present may be included silver, lead, zinc, tin, wolfram, nickel, copper and sulphur. Among those in which she is self-sufficient or has a surplus may be included manganese, monazite, ilmenite, magnesite, mica, chromite, bauxite, beryl and clays.

I cannot in the available time discuss all these, but I propose to follow the histories of the more interesting or more important ones through the two wars, and to draw conclusions as regards a sane mineral policy with reference to the defence of India.

COAL

Last year's President gave you an able address on the Indian Coal Industry, so I need not go very deeply into the subject. Coal, as you all

know, is absolutely essential for industry and transport during times of war. In India the only coalfields at present capable of yielding fuel in large enough quantities to keep Indian industry and transport supplied lie in Bengal and Bihar.

The fortunes of the coal industry in the two great wars of this century have been somewhat different. In 1914-18 aided by ever rising prices there was a steady increase in production from 16,460,000 tons to 20,722,000 tons. The mines were still shallow, and had been little mechanised so that it was possible under the stimulus of rising prices to bring in outside labour, and increase production. In the war of 1939-1945 production rose rapidly in response to higher prices from 27,769,000 tons in 1939 to 29,464,000 tons in 1941. Thereafter there was a serious fall in production from this high level to 25,512,000 tons in 1943. Subsequently, owing to strenuous efforts to increase the production by outcropping and in other ways, there has been a slight improvement.

The principal cause of this fall in production seems to have been shortage of labour due to abnormal conditions which made work in the fields more profitable than in the mines. The mines were also deeper than in 1914 and partly mechanised. This made it difficult to use unskilled outside labour. The machines too were largely of foreign construction and could not be replaced readily during the war.

OIL

Oil is almost as important as coal in the defence of a nation. The known Indian resources of this valuable mineral are quite inadequate to keep her armed forces supplied in time of war. It is true that the search for oil in India is far from complete. It was being prosecuted with great vigour before the war broke out in 1939, but after that drilling was confined to known oil-bearing areas. Subsequently, after the Japanese had overrun the oilfields east of India, this policy was changed and a certain amount of experimental drilling was allowed under Government control. I am not fully conversant with the results of this work, but it was instrumental in bringing to light a new oilfield, which it is hoped may ultimately be of great importance in the Punjab. After drilling into an insignificant looking structure in the Siwalik rocks oil was encountered between 6000 and 7000 feet deep, and appeared at the surface as a gusher yielding some 15,000 barrels a day of hot pitch-like oil. Unfortunately the oil hardened on cooling, and could not be piped in the ordinary way to the refineries at Pindi. It is too early to say yet whether this discovery will be of great importance or not, but other similar structures are known to exist in the same area, and with luck should yield oil also. Normal development work continued in the known Indian oilfields at Digboi in Assam, and Khaur and Dhulian in the Punjab. It resulted in an appreciable increase in production from 81 million gallons in 1939 to 101 million in 1941 falling again to 96 million gallons in 1943.

Presumably the advent of peace and the recent success in the Punjab will cause the search for oil to be taken up again all over India. Whether it will be successful or not remains to be seen. Some success is likely around the frontiers of India. None can be expected in the Peninsula proper. This means that any new oilfields which may be developed in the future are likely to be in range of enemy bombers, or might even be overrun by advancing enemy troops, and cannot be considered altogether reliable sources of oil fuel for Indian defence.

Germany endeavoured with some success to mitigate her oil shortage

by producing alcohol from various crops, and by oil derived from coal. The drawback to relying on oil from coal seems to be that in war the demand for Indian coal becomes so large that it would be difficult to divert any of it for conversion to oil. All the same I think a good case might be made out for extensive research to discover the most economical means of deriving oil from the cheap low grade coals of India, and I have no doubt that the distillation of alcohol from the molasses produced by the sugar industry would be in the interests of Indian defence.

Even if all possible internal sources of oil were fully utilised it is, so far as geologists know at present, unlikely that India could ever be self-supporting during war. She must be prepared to supplement her internal resources by imports from abroad. These must come overseas from Burma, Sumatra and Borneo, or from the Persian Gulf in the west.

IRON ORE

Iron ore is with coke the essential basis for India's steel and munition industry. Fortunately it occurs in profusion in many parts of Peninsular India. It is, therefore, unlikely that shortage of it would affect India's defence harmfully. The real situation in India is that the small known reserves of suitable coking coal regulate the size of the Indian steel industry. Until fuel research enables low grade coals to be used for smelting or new sources of coking coal are made available, the iron industry cannot attain the size that would be justified by the vast Indian reserves of excellent iron ore.

MANGANESE

Manganese is of decreasing importance in war, as is shown by the fact that in the first World War the German steel deteriorated very seriously towards the end of the war owing to the manganese famine, whereas in this war the Germans had learnt to make excellent steel with their own low grade manganese ores, and there was no noticeable deterioration, though the manganese shortage in the final years of the war must have been worse than in 1918.

In spite of this development in Germany high grade manganese ores were essential for the steel industries of all other nations. Difficulties of transport both by sea and by rail in India were acute in both wars and had the effect of greatly reducing the export of Indian manganese and of encouraging the development of manganese mining in Brazil, S., & W. Africa. Whether the manganese industries in these countries will be able to keep the greater share in the world's manganese trade which they have won during the war remains to be seen. On the whole the effect of the war on the Indian manganese industry was probably unfavourable, but there is every likelihood that it will remain in a flourishing state while the unlimited demand for steel for reconstruction continues.

A new deposit which promises to be of importance on account of its low phosphorous content has been developed near Raigudda in Jeypore State during the war. On account of its proximity to the Raipur-Vizagapatam Railway, this deposit is well placed for the export trade.

MICA

Muscovite mica is almost an Indian monopoly in peace time. This is perhaps not so much due to her holding the best and largest deposits in the world, as to her experience in the semi-finishing of the raw material. This requires a very large force of trained labour, which is available in India, but not in other mica fields. As regards ease of mining and quality of mica, there is reason to believe that Brazil now leads the world.

Mica has a very wide range of uses in industry. Perhaps the principal one in the last war was for condensers, many of which are necessary in electrical apparatus, but it was employed for many other purposes also. To give you an idea of the amount of strategic mica used, it is freely stated that 1 maund (82 lbs.) of semi-finished mica was used in a four engined bomber. The quality of the mica needed for a bomber is higher than that needed for ordinary peace time electrical purposes, because the safety of the crew often depends on the high quality of the bombers' electrical apparatus. The fact that the war time demand was very largely for the best qualities of mica threw a very heavy strain on the Indian industry. It proved impossible greatly to improve the Bihar mine production, but a good deal was done to make available an increased amount of good quality mica by more careful dressing of the raw material, though this was done at the expense of size. Increased Rajputana production of good quality mica helped greatly also. The situation was, however, really saved by a great development of production of high grade mica in Brazil. This was achieved at great expense by American engineers and equipment, and it is very doubtful whether Brazilian production will retain in peace time its present important position in the mica trade.

Perhaps a greater danger to the Indian mica trade is the development of substitutes. Owing to war time shortage, especially in Germany, intensive research has been carried out with a view to developing suitable mica substitutes, and a good deal of success has been attained. For instance, a good artificial insulator is now available for use instead of mica in the segments of commutators, and wrapping mica is no longer used in the best quality sparking plugs. Germany succeeded in using substitutes for mica over a wide field in the electrical industry, and any useful discoveries which she made are now common property. This all sounds ominous for the Indian mica trade, but I do not think it is as serious as it sounds. It must be remembered that Germany evolved these substitutes driven by the stark necessity of war, and helped by unlimited slave labour. Some of the substitutes will no doubt continue to be used for special purposes, but none of them has the same general utility that mica has, and their continued use in peace time will depend largely on costs.

One great advantage which mica has over any of the new substitutes is that the world's electrical industry is accustomed to its use, and all its apparatus is designed for it. Any change over to substitutes would, therefore, involve change of design with consequent great expense. The general impression which I got in London is that the Indian mica trade will continue to retain its dominant position in the world's electrical industry provided they keep their costs down. The change over from war to peace is likely to be a difficult one for the trade, as the demand will now be for a greater proportion of lower grade mica, and larger sizes. This may suit Madras and Rajputana, but will bear heavily on Bihar.

The reason why manufacturers favour large size is of some interest. The actual mica pieces used by the electrical trade are mostly shapes of about half inch diameter, and could easily be stamped from size 7 mica. The reason that large sizes are favoured is that, when once they are in position, the girls who work the machines can stamp out ten or a dozen pieces without further manipulation, and with very little waste. If No. 7s were used for the same purpose, a girl would have to place a new piece of semi-finished mica under the stamp every time she turned out a finished piece, and her production would be relatively slow. There would also be a lot of waste mica. The possibility of using No. 7s for the manufacture of finished mica in India

with the cheaper labour there available suggests itself. A ready market for No. 7s in India would be of great assistance to the miners, and would help to keep costs down. This development is probably not possible until an electrical trade using large amounts of finished mica develops in India.

WORK OF THE GEOLOGICAL SURVEY OF INDIA ON MICA DURING WAR

Early in the war the assistance of the Geological Survey of India in obtaining mica for the allied nations was sought, and the Department was obliged to set up a buying organization to supply the requirements of the allied nations.

In 1942 the Geological Survey of India handed over the buying of mica to a Joint Mica Mission sent out by the British and American Governments, but the responsibility for keeping up or increasing the output of mica still rested with them.

In order to encourage the output of good quality mica the Department set up utilization branches in Kodarma, Gudur and Ajmer staffed mainly by mining engineers. They were expected to assist the mine owners over all forms of equipment and transport, to advise them on mining methods, and do anything possible to make mine production easy.

Stores and equipment were obtained from America under lease/lend by the Joint Mica Mission, and policy as regards the distribution of these remained in their hands. The utilization branches collected the necessary information about the mines on the basis of which the limited supplies of stores and equipment were divided.

My experience was that this somewhat unusual arrangement worked well in practice. The Joint Mica Mission decided that Bihar, which produces a higher percentage of first class mica, than any of the other Indian mica fields, should have first pick of the equipment. Thus in Rajputana we only got what was left over after Bihar had its pick, but we were free to distribute what we did get to the best advantage.

My view was that the Joint Mica Mission were making too sweeping a generalization and that the best Rajputana miners could produce far more first quality mica than the poorer Bihar ones, and, therefore, should have had a higher priority in the allocation of the equipment. The Joint Mica Mission, however, never accepted my opinion, and we were forced to work under great difficulties with very poor equipment.

In spite of this I think the Rajputana utilization branch was well worth while. When it opened up, the production of mica in this area was low, and the quality was largely black spotted. Mining was primitive, even as mica mines go. There were many disputes over leases due to misunderstandings between the authorities and the miners. Tools were almost unprocureable, and railway transport very difficult.

At first the utilization branch was treated with much suspicion, as it was feared that we were going to occupy the mines on behalf of Government but after a few months this suspicion died down and we were able to do much to mitigate, if not remove, the difficulties retarding mica mining in Rajputana.

The quality of the mica produced was greatly improved, and the quantity kept at a high level. Many disputes and misunderstandings with the authorities were settled by the Department, which was regarded as an impartial referee with mining knowledge. Stores and equipment were distributed where they were most needed, and difficulties with the Railways overcome.

The only failure of the Department was to make a great improvement in mining methods, but here the failure was relative. We did introduce the use of gelignite, and an improved drilling bit, and we did succeed in getting some of the miners to work their properties on better lines, but, perhaps because the necessary equipment was almost unobtainable, I cannot claim that there was any great all round improvement in mining, and in the end, on account of the shortage of labour which became serious in 1943, the expected improvement of output was not fully realised.

The experiences of the utilization branches in Bihar and Gudur were not so happy, as there are so many discordant voices in the mica trade in those areas that it was impossible to please everyone, but there is no doubt that they performed a most useful function there in distributing the available mining stores and equipment to the best advantage, and were also very helpful to the mica mining industry in many other ways.

The only interference in the mica industry forced upon Government by the war was the taking over from Messrs. Chrestiens of the mica area at Mahesri. The reasons for this were, firstly that agrarian agitation in this vicinity had made it impossible for Chrestiens to work the mica mines there, and secondly that the Joint Mica Mission were particularly anxious to obtain the production of this area, which is considered to be of excellent quality.

After Government took over, the agrarian agitation ceased, and a regular if disappointing mica production was obtained. This was sent in to a Government factory at Giridih in charge of Mr. Sarat Ghose, and was there worked up to the Joint Mica Mission standards. The whole operation involved Government in very considerable financial loss, but this was perhaps justifiable on the score of defence.

I have recently heard in London from manufacturers of finished mica that they had had to handle consignments of mica from many sources during the war some of which proved of very inferior quality, but that any which came from the Government factory were excellent.

In conclusion I may add, that all are agreed in London and America, that, though stocks were at times critically low, the allied munitions industry was never actually held up for want of mica.

BERYL

Copper alloys with beryllium have the peculiar property that they never suffer from fatigue. On this account they proved in the last war the ideal material for certain small bearings on aeroplanes and for springs.

Unfortunately the rare mineral beryl is practically the only mineral containing beryllium, and even it contains but 5% of this element. Moreover, the manufacturing process is extremely complex, and has only been developed in the U.S.A. and Germany. As a result of the manufacturing difficulties, and the small scale of operations it was only possible to offer rather a low price for the mineral.

During the war the U.S.A. was, however, very anxious to get beryl and India was able to help by supplying about 1000 tons a year for two years. The price paid was in the neighbourhood of Rs.12/- per maund (82 lbs.) f.o.b. Bombay. Two or three producers made a good profit at this rate and large numbers of collectors made quite useful sums.

I do not think, however, that beryl could be produced indefinitely at this price. The war time production was mainly from shallow diggings.

and quarries. If it became necessary to mine, a very much higher price would be necessary.

It was never possible for me to get accurate figures of the amount of beryl in a pegmatite, but few contain as much as 2% of the mineral. Tin occurs in much larger deposits containing about 3% of the mineral, and cannot be mined at a price much below £150 per ton. Although the two minerals are totally different I do not think beryl mining in India could be contemplated at much below £100 a ton which is about Rs. 50/- per maund.

Whether beryl mining will become an established peace time industry or not cannot be foretold, but if the makers of beryllium alloys are willing to give the price, there are several areas in Rajputana where beryl might be mined. I think it more likely, however, that science will evolve other means of attaining the same results using raw materials which occur in greater abundance.

It was at one time thought that beryl could be obtained in quantities as a by-product from mica mining, but experience during the war showed that not more than 10% of the beryl produced came from this source.

Considerable work was done by the Rajputana party of the Geological Survey of India in an effort to increase the production of beryl. The most important work was to stimulate interest in the mineral among the numerous mica miners and prospectors in Ajmer, Jaipur and Udaipur. Formerly few of them were interested in anything but mica, but as the result of our advertising many of them became beryl-minded, and a fairly intensive search for the mineral was made. This led to the discovery of very numerous small surface deposits and a few larger ones, which may prove of permanent value.

The Rajputana party also supervised some surface workings and obtained interesting figures as to the cost of working such deposits. Incidentally in their search for beryl many interesting minerals such as crystals of monazite, nodules of pitchblende, crystals of cassiterite, chrysoberyl, and fluorspar were found. Some very interesting intergrowths of columbite-tantalite with beryl, felspar and mica were also obtained. Columbite-tantalite was also identified in many localities in Rajputana. Unfortunately none of these rare minerals proved to be present in workable quantities, though Mr. Wahid Nur Khan actually did produce about 10,000 lbs. of columbite-tantalite.

A valuable discovery made as the result of the intensive war time search for beryl was a locality in Udaipur where beryl of the emerald variety occurs. Emeralds won in this area have since been auctioned for several lacs of rupees.

ILMENITE

Ilmenite is a common mineral in many parts of the world, but nowhere can it be obtained so cheaply as from the beach sands of Travancore. In peace time it is the principal source of titanium white, which is increasingly used in white paints. Unfortunately the decorating trade was brought to almost a complete standstill in war time, so that the use of ilmenite was greatly curtailed. Transport difficulties were also great so that India's exports fell from 236,000 tons in 1938 to 24,000 tons in 1942. The loss of this very large quantity of ilmenite in the world economy was largely compensated by a high production of the mineral in mines in the U.S.A. The prospects of this industry in peace time appear rosy, because the world has six years of dilapidations, and many years of building construction to catch up before it returns to normal, and white paints for these purposes are bound

to be in great demand. Besides, the monazite sand associated with ilmenite is now likely to be very valuable.

WOLFRAM

This mineral is principally found in Burma, but it is particularly interesting as illustrating the vicissitudes experienced by minerals during war. It was not exported from Burma till 1909, but by 1914 Burma was the largest wolfram producing country in the world. The unprecedented demand for the mineral in the 1914-18 war led to a wild boom, and the output, 2,243 tons in 1914, rose to 4,542 tons in 1917. This increase was achieved in the tropical parts of Tavoy and Mergui by importing a large Chinese labour force, by an extensive road making programme, and by employment of modern machinery.

After 1917 the wolfram deposits of China came into operation, and in a very few years they ousted Tavoy and Mergui from the world's market. In the years following the slump of 1931, Burma re-appeared as a large exporter of wolfram principally owing to the successful operations of the tin-wolfram mines at Mawchi. The outbreak of war in Europe increased the demand for wolfram, and the mines at Mawchi and surface deposits in Tavoy and Mergui were doing very well until the sudden invasion of the Japanese closed them.

India now turned to her own deposits of wolfram for the material she required, and a certain amount of success was achieved in developing the old workings at Degana in Rajputana, and the surface workings near Kalimati in Bihar. The highest production was 79 tons in 1942. This was a good deal better than the Indian production achieved in the 1914-18 war.

Unfortunately the world learnt to work with tools merely tipped with tungsten steel and not made of it. There was, therefore, no longer a world shortage of the mineral, and India's frantic efforts to obtain it after the fall of Burma were brought to nought. Presumably the small known deposits of wolfram in India will now lie fallow till the next sudden demand for it arises.

SILVER, LEAD, AND ZINC

The mining of silver, lead and zinc like wolfram was in the war of 1914-18 almost confined to Burma. Under the influence of high prices there was a fairly rapid development at the Bawdwin mines from 10,548 tons of lead and 236,446 oz. silver to 18,995 tons of lead and 1,970,614 oz. silver. There was also a considerable accumulation of zinc concentrates at the mine. These had formerly been shipped to Hamburg, and so could not be smelted during the war.

After 1918 attempts were made to arrange for the smelting of the Bawdwin zinc concentrates in India without success, and finally they were shipped to Cardiff for smelting. This was the situation at the time when the Japanese overran Burma.

Government of India then became very anxious about supplies of these metals for war purposes, and asked the Geological Survey of India whether it would be possible to develop a zinc industry in India in a hurry.

The Geological Survey of India suggested opening up the old silver-lead-zinc mines at Zawar in Mewar State. This was under the circumstances quite a reasonable proposition because the remains of ancient mining in this area are very extensive, and certainly give the impression that the worked out deposits were on a great scale.

Government acted rapidly. They arranged to take over the lease of the area from the lessee Mr. Mohta. They engaged most of the staff of the Mawchi mines, and as much of its personnel as they could find. Bhils and other local labourers were rapidly collected, and in a very short time a mining camp was erected, and 5 adits designed to cut the lodes below the largest of the ancient workings were started.

The high speed at which everything was done reduced the amount of preliminary reconnaissance, and as a result there was a good deal of wasted work which might have been avoided in more leisurely circumstances. On the whole, however, I think the operation was carried out with commendable speed and decision.

In four out of the five adits the results were extremely disappointing, only small amounts of lead and zinc ores being encountered. In Adit No. 3, however, a mass of zinc-lead ore over 100 feet thick averaging about 4% of metal was found. This was considered too low a grade to be a practical proposition in war time, and, after extensive and partially successful efforts to locate richer lodes, the whole project was finally considered unlikely to produce useful quantities of the required metals before the end of the war. Accordingly it lost its priority. Work was, however, continued up to the beginning of 1945.

The final result was to demonstrate the existence of a zinc-lead lode at least 500 feet long with an average width of about 10 feet, averaging over 10% metal, another richer but smaller lode containing native silver in places, a third small but rich zinc lode, and an indefinite but large amount of zinc ore containing 4% metal.

Geological opinion agreed that the lodes in all probability continued in depth, and this was borne out by 2 winzes sunk to a level 100 feet below the main one.

Government decided that the results were inconclusive, but that further government work could not be justified. They then sold the lease back to Mewar State at a rather low rate hoping that capitalists would think the results sufficiently promising to go on with the work. I understand that Mewar State has since sold the lease to Indian capitalists at a slightly higher price than that which they paid to Government. This means that the capitalists should be well placed to carry on exploratory work, but whether they will be in a position to found an Indian zinc-lead industry is likely to depend as much on world prices and hydro-electrical developments, as on the results of the exploratory work.

SULPHUR

Sulphur is at the present day the basis of the heavy chemicals industry, and is absolutely essential for the production of explosives. For a country of her size India is singularly poor in this essential raw mineral. It is of course found as a sulphide in many mineral deposits all over India, but, so far as is known, nowhere in quantities sufficiently large to be of much help to modern industries. It is also found near the Persian border of Baluchistan as native sulphur, and in the Salt Range, Rajputana, and Madras in the sulphate gypsum.

It has not been extracted in peace times from any of these sources because it is much cheaper to import it from Italy, America, or Japan. When two of these sources were shut off in the late war and the third was almost closed owing to the precarious communications between the U.S.A. and India, great difficulties were experienced in India, and if there had been a really large heavy chemicals industry, it would have been greatly reduced.

To combat this state of affairs, Government opened up sulphur mines at Koh-i-Sultan on the Persian border, and for some years the produce of these mines augmented India's limited imports of refined sulphur. The ore extracted generally contained from 40 to 50% sulphur, but it proved at the time impossible to refine this at the mines, and very difficult to do so at consuming centres. It was largely used in the raw state in sugar refineries, but the high freight rate from the Persian border to the refineries for a product less than 50% sulphur made it uneconomic as compared with foreign sulphur. Moreover, the 50% of impurity caused considerable trouble in the manufacturing process.

When American sulphur became plentiful again it was decided to stop the work at Koh-i-Sultan largely because it was using much precious railway transport, but also because manufacturers did not like 50% sulphur, even though it could be sold at a lower rate than American. In the end it was decided to sell the deposit. Since then some work on refining of the sulphur has been done by Mr. C.V. Thornton formerly manager of the mines, and a process for the refining of the sulphur has been patented, which might make it economically possible to refine the sulphur at source. If this process proves practical on a large scale, it is not unlikely that it will be economic to continue the mines at Koh-i-Sultan in peace time.

The precarious food situation in India as the result of the war has led to a demand for fertilizers, especially ammonium sulphate, and Government has decided to produce this chemical on a great scale in Bihar. The location of the works next the coal in Bihar has been much criticised, but I am bound to say that I believe it to be the right situation for such an industry. At the same time it is very questionable whether an industry involving the transport of half-a-million tons of gypsum by rail from the Salt Range to Bihar can ever compete with similar industries in foreign countries where gypsum and coal are found in juxtaposition. If the ammonium sulphate industry does become firmly established in Bihar, the possibility of extracting sulphur from the gypsum would be worth investigating.

MONAZITE

The last mineral which I propose to mention is monazite. This mineral was in considerable demand during the 1914-18 war for thorium needed in gas mantles, and over 2000 tons were produced in 1918. After the war electric lighting gradually replaced gas. The demand for thorium for gas mantles failed and production of monazite ceased in 1925.

Since then monazite has not been specially worked, but there has been a regular and increasing production of it as a bi-product in the rapidly increasing trade in ilmenite. The peak production was in 1938 when 5,221 tons were produced as a bi-product from 252,000 tons of ilmenite.

During the war, to save freight Travancore ilmenite was replaced in America by locally mined ore with the result that the production of monazite fell off to about 2000 tons.

The strategic importance of monazite lies in the fact that it contains a variable percentage of thorium which may be used like uranium as a source of atomic energy.

Monazite sands are known to occur along the coast from the Chilka lake to the Godavari delta and in much larger amounts in Travancore, in the Tinnevely district, and in Ceylon.

Very little is known about the source of the monazite. The mineral has been found in pegmatites in Travancore and other parts of India and is

sometimes associated with graphite, but it is rare, and as pegmatites are not common in Khondalite areas where the monazite sands are chiefly found, it is unlikely that much of the monazite has originated in pegmatites. It is much more likely that it is derived from the Khondalites or associated charnockites and granites. Possibly it is a common accessory mineral in all these rocks, but as small grains of it can easily be mistaken for other mineral grains, it has not yet been identified.

The first problem before Indian geologists will be to locate the source of the monazite with certainty, and find out if it ever occurs at source in workable amounts. The next and more difficult one will be to check up all the deposits along the coast, among sand dunes, and along rivers, to find what percentage of monazite each contains and the percentage of thorium in the monazite. Finally it will be necessary to come to some conclusion as to the reserves of monazite, and the rapidity with which those reserves are replaced by new mineral grains derived ultimately from the erosion and degradation of the rocks.

To get complete answers to these questions for all India would probably involve more man-hours work than can be reasonably given to the problem, and it might take so long that the world demand for monazite would have ceased by the time that the work was finished.

A more reasonable line of approach would be to make a rapid examination of India's coastal areas with a view to the location of the best monazite ores, and then to concentrate on a thorough investigation of these.

On the results of such an investigation Government's policy would naturally depend. In the meanwhile I consider that licenses to work and export monazite should be severely restricted.

CONCLUSIONS

I have now given you an account of the vicissitudes of some of the more important and interesting Indian minerals during the two wars. I fully admit that this account is incomplete and deals with minerals with which I have had some personal experience more fully than can really be justified. It remains to draw correct conclusions from this, so that India's mineral wealth may make the maximum contribution to her defence in the future.

I think you will all agree with me that the coalfields of Bengal and Bihar must be the heart and core of India's defence. They keep her railways going and her steel industry working. Their loss would paralyse the Indian armed forces as surely as the loss of the Ruhr and Silesia paralysed the German Wehrmacht. It follows, therefore, that in any schemes for the defence of India the safety of these coal bearing areas has priority over all others.

Fortunately for India these coalfields are thousands of miles from the nearest land frontiers, so that it is unlikely that they could be overrun by enemy land forces. They are also well dispersed, and therefore not easy to injure by bombing from the air. On the other hand, they are exposed to landings from the sea, and I think it has been adequately proved in this war that such landings are perfectly possible when organised by any great industrial nation which has managed to seize command of the sea and air. That this situation is a real possibility was proved in the last war when the Japanese held command of the Bay of Bengal for a short period, and were only prevented from landing on the Bengal and Orissa coasts by pre-occupations in the Pacific, and absence of adequate preparations.

The defence of the coalfields therefore calls for sea and air strength sufficient to hold the Bay of Bengal against all possible opponents. India's shortage of oil involves large imports which must come either from the east or the west. To insure the arrival of these, naval and air supremacy in the Indian Ocean is also essential. The effect of atomic weapons in the future is not likely to alter this, as the only mineral in India which can conveniently be used for such purposes is found on the Indian coasts, and will need naval and air protection.

Ground forces will of course also be necessary in support of the naval and air strength, and to protect the frontiers against any enemy who has the temerity to ignore India's natural defences, but they will necessarily be a second line of defence.

Presumably India's naval and air defence is reasonably well assured so long as she remains a part of the British Empire, but what her position would be as a completely independent country is hard to say.

The disastrous fall in production of Indian coal during the war calls for measures in peace time, which would prevent its recurrence in future. While India's mines are worked by labourers who are primarily farmers and secondarily miners, they are bound to desert the mines in favour of the farms whenever it pays them. What is needed is permanent miners proud of their profession and realising to the full its importance to the community both in peace and war. Such a labour force would not be tempted to desert the mines by temporary high wages in some other trade.

The evolution of a force of mine labour in India with a high sense of their national importance will be difficult as long as the miner is regarded as an aboriginal of no practical importance. I think the probable solution will be found in employing labour of much higher social status and education, and in mechanizing the mines to the maximum possible degree.

The machinery necessary for mechanizing the mines should as far as possible be of Indian manufacture, because replacements of foreign machinery in war time are difficult to arrange.

The sulphur situation in war time needs careful consideration. The search for more and better sources of sulphur must proceed, but it is unlikely that these can be made to yield sufficient sulphur for India's peace-time needs at a price comparable with that of American or Sicilian sulphur. All sources should however be known, and preparations to work them in the event of war should be made in advance. The actual shock of war could be taken up by a strategic reserve of sulphur held by government against such a contingency.

I think I have shown how the importance of minerals waxes and wanes, and that few of them are likely to be essential for long. I conclude from this that it is normally wise to work minerals as fully as possible, because if there are artificial restrictions to production, substitutes are likely to be evolved, which may and often do make a mineral valueless, which could have been worked profitably before the substitute became available.

I don't think it is normally possible to foretell in advance all the minerals that will be strategically important during war time. It is, therefore, necessary for any country to have as full a knowledge of its mineral wealth as possible, whether this be workable at any particular period or not. Money spent in amassing this knowledge in peace time ensures the best use of a country's mineral wealth in war, and, therefore, should be chargeable to some extent to defence.

SECTION OF BOTANY

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BOTANY AND HUMAN WELFARE

(Delivered on 3 January, 1946)

'And God said, Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree, in which is the fruit of a tree yielding seed ; to you it shall be for meat.'

—Genesis 1.29.

Man is still basically dependent on plants for subsistence. For plants are the sole creators of food and clothing materials ; man and other animals are merely "cultivators, transformers, processors or purveyors". When we consider the manifold other uses of plants and plant products including their service in building and conserving soil, in controlling floods and erosion and in increasing the esthetic enjoyment of life, we can assert, without fear of contradiction, that botany holds a foremost place among the sciences. Botanical science can bestow upon man better varieties of crop plants and can show the best methods of protecting them against diseases and other hazards.

It is well known that the bulk of our population lives on the margin of subsistence, and our problem is how to raise more food and better food. The botanical sciences, with the rapid progress they are making and profiting by advances in other related sciences, can solve this problem. But to accomplish this there must be adequate provision for research, including basic research, to discover facts and formulate principles ; for experimentation to determine when, where and how they can be applied profitably ; and for education, to incorporate them into practice and capitalize on their value.

Some of the important directions in which botany can aid human welfare are briefly discussed in the following sections.

PLANT INTRODUCTION

Plant introduction began with the importation of wholly new crops from other countries, and in its history romance vies with economic significance. Many of the principal crops entering trade have been introduced into the part where they are now extensively grown from some other region of the world. It is a striking fact that, until comparatively modern times, the Old World and the New World had few cultivated plants in common. The great majority of the cultivated plants of the two hemispheres are represented by entirely different genera and before the days of Columbus many cereal and leguminous crops cultivated in the Old World were unknown in America, while many American crop-plants had not been intro-

duced to the Old World. Thus for instance, rubber, which is mainly grown in the Far East, originally came from the Amazon region of South America. Sugarcane, which is perhaps the dominant crop of the West Indies, came from the East. Cinchona, a native of South America, is largely cultivated in the Dutch East Indies. Potatoes came to Europe from South America. Many other examples can be given. Even in comparatively recent years, there have been examples of successful introduction of new crop plants; for instance, the soybean has been taken from Manchuria to America and to parts of Europe, where it is now an important commercial crop. It is clear from these that the possibilities of plant introduction and acclimatization are not yet fully exploited. Certain crops which are much valued in Peru, Chile and Brazil, are yet unappreciated elsewhere, e.g., ulluco (*Ullucus tuberosus* Lozano), oca (*Oxalis tuberosus* Molina), etc.

Modern practice is mainly concerned with the introduction of new varieties of crops already grown in the country.

It has been found that, in the case of many crop plants, wild or little-known allied species or varieties exist and in several cases these are resistant or immune to the devastating diseases which attack their cultivated relatives or they possess some other attributes which render them desirable material for breeding. If the genes conditioning the disease-resistance and other desirable attributes of the wild or semi-wild species could be incorporated in the commercially cultivated varieties of crop plants by hybridization, many of the most pressing problems of crop production would be solved. To facilitate such work, modern plant breeders are constantly on the search for new genes for use in plant breeding.

To achieve this object, the agricultural departments of several countries, notably Russia, U.S.A. and Germany, have organized expeditions to different parts of the world to make collections, in their probable places of origin, of as many varieties of crop plants and their wild allies, as possible.

The study of the probable places of origin of cultivated plants discloses the striking fact that most of them have come from certain restricted zones in the Old and the New Worlds. Among the most important of these areas are the regions between the foot of the Western Himalayas and the Hindu Kush, certain parts of China, Asia Minor, and Abyssinia, in the Old World; and Central America (including Southern Mexico) and Peru, Bolivia and Chile, in the New World. In their respective centres of origin, cultivated plants display a wealth of varietal diversity which is not to be found elsewhere. A characteristic feature is that these primary centres frequently include a large number of genetically dominant characters. As we proceed outwards towards the periphery of the region of maximum diversity, forms with recessive characters become more evident.

The researches of Vavilov and his co-workers have shown that the region of north-western India and south eastern Afghanistan is the place of origin of the soft and club wheats and also of many other field and garden crops, e.g., rye, pea, lentil, beans, flax, carrot, etc. The 28-chromosome group of wheats has had an entirely separate centre of origin, in Abyssinia. The eastern Asiatic region has probably seen the origin of rice, soybean, and some of the millets. In the New World the rather restricted territory of Central America (including Southern Mexico) is the home of such plants as maize, teosinte, the common bean, annual pepper, agave, anona, sapota, papaya, etc. Tobacco probably originated in South America. The potato plant probably had more than one centre of origin. While the island of Chiloe and the neighbouring islands of the coast of Chile are probably the

centre from which the common cultivated potato originated, many cultivated and wild species have originated in the Peru-Bolivian tableland.

It will be apparent that many of the important centres of origin are associated with the tropics or sub-tropics and the presence of mountains. This may perhaps be connected with the fact that in such regions an optimum of moisture, heat, light and substratum have afforded favourable conditions for the origin and accumulation of varietal diversity. Mountainous areas tend to act as isolators and thus may have played a part in the differentiation and divergence of species and varieties. An interesting speculation that cosmic rays might be responsible for the greater diversity and density of species near the mountain tops has been advanced by Dixon, Hurst and, more recently, by Hamshaw Thomas. The cosmic rays are particles of very great energy which are constantly reaching the earth in very great numbers and closely resemble the x-rays in their properties and effects. As x-rays are at present the most efficient agents known for the artificial production of mutations, it appears possible that cosmic radiations may have been a factor in the production of varieties by direct action on the germ plasm. It is interesting to note that the centres of origin of cultivated plants are also often near the centres of ancient civilizations.

With the acceptance of the concept of primary centres of origin of cultivated plants, the expeditions referred to previously have naturally been directed to the probable centres of origin of the plants of which it was desired to obtain further material. The Russians under the able leadership of Dr. Vavilov, Director of the Institute of Plant Industry, Leningrad, have during the last decade carried out this search for new genes on an extensive scale and in the most systematic way not only in their own country but in a great part of the Old and New Worlds. They sent out expeditions to various parts of Russia, Asia Minor, Caucasus, Transcaucasia, Turkistan and Siberia, as well as the outlying areas of Sinkiang and Mongolia, North-Western India, Afghanistan, Persia and Abyssinia, while in the New World in 1925 and 1926 they sent expeditions to Mexico, Guatemala and Columbia and in 1927 and 1928 to Peru, Bolivia and Chile. Many hundreds of new varieties, both wild and cultivated, have been introduced into Russia and these contain many thousands of new and valuable genes.

To give a single instance, potato breeding has been revolutionised by the discovery in Central and South America of a large number of cultivated species (hitherto unknown and totally distinct from the common cultivated species, *Solanum tuberosum* L.), and wild species. Several of these species possess valuable characters not present in the genetic constitution of *S. tuberosum*. Thus *S. demissum* Lindl., *S. antipovicii* Buk. and *S. neoantipovicii* Buk. are immune to the dreaded late blight caused by *Phytophthora infestans* (Mont.) de Bary. *S. acaule* Bitt., *S. demissum*, *S. ajanhuiri* Juz. et Buk. and a few others are frost resistant. *S. rybinii* Juz. et Buk. is resistant to some virus diseases and is also free from dormancy of tubers. *S. phureja* Juz. et Buk. has an unusually high protein content and *S. andigenum* Juz. et Buk. contains genes for high yield, and a certain amount of resistance to disease. Potato breeders are busy attempting to transfer the genes determining these attributes to the common commercial varieties.

This vast wealth of material has entirely altered our views regarding the varietal diversity of many important crops. For instance, prior to the Russian expedition to Abyssinia in 1927, the general belief was that the 42-chromosome wheats possessed the greatest degree of variation. This

expedition, however, revealed such a number of botanical varieties and varying characters in the 28-chromosome wheats that the former view has had to be considerably modified.

Here mention may be made of a few examples of the achievements of plant breeding in other countries resulting from the exploitation of wild plants. Introduction followed by subsequent breeding has been responsible for the varieties on which the American-Egyptian extra-long-staple cotton industry is based. Many of America's leading varieties of wheat, oats, barley and rye are derived from introductions from the Soviet Union, Australia and India. The greatest advances in the improvement of forage crops by breeding grasses and legumes in that country have come largely from the introduction of foreign varieties. It may be mentioned here that Ladak Alfalfa from India which was found to be resistant to cold and drought was one of the basic varieties in the breeding of these crops. By using a mildew-resistant variety of melon from India, the Americans have built up a high quality melon with disease resistance. The sugarcane production in Java which was faced with extinction owing to the ravages of the *sereh* disease, was saved by the introduction and utilization in breeding of a disease resistant wild variety of cane from India bearing the name *Chunnee*. It is easy to multiply instances of the beneficial results that have resulted and are expected to result from the use of wild and little-known plants in plant breeding. Therefore it is needless to emphasise the importance of exploration and introduction of plant material for the economic development of a country.

The work of plant exploration and introduction is vested in well equipped Bureaux in countries like America and Russia. The establishment of a similar Bureau of Plant Introduction in India is long overdue. The main function of the Bureau would be to arrange for the introduction and study of plant material from abroad and from inside the country (the latter by exploring the country for its plant wealth) with the ultimate object of finding new crops and for providing suitable breeding material for production of superior varieties of crops and other plants. For collection of material the Bureau with the help of its substations and in collaboration with Universities and others interested in plant collection would undertake surveys in the country and collect suitable material. The Bureau would also keep in touch with plant exploration and introduction organizations and with similar Bureaux in other countries and arrange for the introduction of foreign material.

The plant materials so collected would be studied in regard to their adaptability, inherent useful qualities and their capacity to transmit them when crossed with the cultivated plants. Their reaction to different environments and to diseases and pests would also be tested and periodical lists of material available for plant breeders and others in the country will be published.

PLANT BREEDING

India was famous in ancient times as the great storehouse not only of diamonds and gems but of spices and sugar and other plant wealth. It was this richness of nature's products that tempted Columbus and Vasco da Gama to sail the unknown oceans to try and find the way to India.

Since then, however, the population of India has increased many times and many more mouths have to be fed on the products of the Indian soil; a large area of new land has therefore had to be brought under the plough.

Unlike what has happened in other countries, in India increase in the acreage under cultivation has been accompanied by decrease in average yields. The case of wheat may be cited. In the last 40 years alone the wheat land has increased by 40 per cent and in the same period the average yield per acre has decreased; the result is that the country is still deficient in respect of its food grains. The health of the farmers, who constitute the majority of our people, is at a low level owing to the deficient production of accessory foods like fruits and vegetables. It is imperative therefore to take urgent steps to increase food production.

Although there are several scientific methods of increasing the returns from the land, "there is only one which makes no demands on the purse, or the skill, or the intelligence, or indeed on anything more than the obedience, of the cultivator. It is therefore the only one which requires no change in the general system of land management. The method is plant breeding." It is therefore the method which must have the widest possible application in India.

Man from early times began to gather seeds from the fields and to plant them for his own use; by a slow and crude process he built up the major agricultural types of plants that we have to-day; he took the plants that seemed to yield the most and increased them and discarded the others. Even to-day the plant breeder uses the method of simple selection, and the sorting out of the best from the mixture of varieties grown by the farmer, especially in countries which are agriculturally not highly-developed, has been an important method of crop improvement.

After this first sorting out, further progress is possible by the method of hybridization. Formerly crossing tended to be limited to combinations between varieties or closely-related species because wider crosses often gave rise to sterile hybrids, which, except in the vegetatively-propagated plants, could not be used further. To-day however, plant breeding, which used to be regarded as more art than science, is no more "a game of chance played between man and plants". It has by its own advances and with the help of discoveries in genetics, cytology, physiology and mycology, elevated itself to the position of a recognised science and the modern plant breeder is a highly trained technician. We can now re-mould the heredity of plants: by using drugs and x-rays and other devices, we can make plants larger or smaller, quicker or slower growing, annual or perennial; we can also by suitable chemical treatment make sterile hybrids fertile. With such a promising vista of the shape of things to come, let us see what is the position of plant breeding in India.

Scientific crop breeding became possible in India—as elsewhere—only after the re-discovery of Mendel's laws of inheritance, in 1900, when, in the words of Hunter and Leake (1933), "for the first time the plant breeder was offered an opportunity of producing new plants better suited to the many and very varied requirements of agriculture and commerce in an orderly manner." The foundations of plant breeding work in India were laid by such pioneers as the Howards, Barber, Leake, Gammie, etc., and as a result of their labours and of those who succeeded them, a large number of improved strains of a wide variety of crop plants is available. These have been produced chiefly by the time-honoured methods of simple selection and hybridization and the main direction in which improvement has been attained is higher yield and quality of produce. To get an idea of what has been actually achieved and what remains to be done let us take the case of the important groups of plants.

BREEDING IN THE SELF-POLLINATED CROPS

After rice the most important food crop under this category is wheat. Five species of wheat occur in India, namely, *Triticum vulgare* Host, *T. sphaerococcum* Perc., *T. durum* Desf., *T. dicoccum* Schubl., and *T. turgidum* L. The first two are members of the bread-wheat group with $2n=42$ chromosomes, and the remaining three belong to the emmer group with $2n=28$ chromosomes. Commercially, only *T. vulgare* and *T. durum* are of real importance, especially the former which is dominant in the great wheat area of northern India.

The earliest phase of the wheat investigations was the survey and collection of the existing wheats, an undertaking which resulted in the accumulation of much useful information and revealed the richness of the indigenous material. Side by side with the surveys, the breeding of improved varieties was taken up. This work, which was initiated and carried out at the Imperial Agricultural Research Institute by the Howards, assisted by A. R. Khan, led to early success in the selection from indigenous forms of the famous Pusa 4 and Pusa 12 wheats. Hybridization also was resorted to at an early stage of the investigations, and most of the improved strains produced later are of hybrid origin.

In the earlier work in India, emphasis was laid on yield and quality of grain; Indian wheat then had a poor reputation abroad because the wheat exported from Karachi mainly comprised a mixture of soft white sorts, poor for bread-making and deficient in flavour. As a matter of fact, India, owing to the great age of her agriculture, is specially rich in varieties, and many qualities of grain are available. In the case of the hard wheats, the conditions of rapid ripening, the soil, and the dry climate all further the inherent quality in producing a hard vitreous grain of high protein-content and high quality for bread-making, and probably few wheats in the world can equal the handsome appearance of some of the large-grained, translucent, amber-coloured Indian varieties. A series of experiments carried out by the Howards with the co-operation of H. M. Leake and A. E. Humphries and, later by F. J. F. Shaw with the co-operation of E. A. Fisher demonstrated conclusively that there exist Indian wheats which are equal in quality to good Manitoba wheat.

Taking the existing improved wheats as a group, they have certain characteristics in common. They are good yielders (they have given yields of more than 40 mds. (3,280 lb.) per acre under conditions of good cultivation), give grain of excellent quality, and have from fair to good standing-power. Although some attention has been paid from the very beginning to disease-resistance, much could not be done in the direction of deliberate, planned breeding for disease-resistance until further advances in the aetiology and epidemiology of Indian wheat diseases made reliable and artificially-controlled tests for disease-reaction possible. In the case of the rust diseases, the earlier work was perforce carried out in ignorance of the physiologic races occurring in India, and there was no means of discriminating between true resistance and 'escapes' due to lack of inoculum of the parasite or other causes. Considerable scope therefore existed for improvement in this and other respects, and there was a compelling need for varieties resistant to the maladies which inflict such heavy losses from year to year. Although, fortunately, there is no serious insect pest of wheat in India in the main wheat-growing areas (with the exception of termites which are often troublesome in the early stages of the crop) the fungous diseases are exceedingly important, especially the rusts and smuts.

Breeding for rust resistance. In India all the three wheat rusts, namely, black, brown and yellow, caused respectively by *Puccinia graminis tritici* Eriks. and Henn., *P. triticea* Eriks., and *P. glumarum* (Schm.) Eriks. and Henn., ravage the wheat crop, and according to an estimate made about 40 years ago the annual loss to the country from this cause is not less than Rs. 40,000,000.

Mehta has shown that, in the heat-soaked plains of India, the rust spores are killed out during summer, and the wheat crop is infected afresh each year by spores floated down by currents of air from the Himalayas and other mountains, where wheat is grown up to an altitude of about 9,000 ft. above sea-level. If, therefore, only rust-resistant wheats were to be grown in the hills, the chances of infection in the plains would be reduced, apart from the value of such wheats to the hill farmers themselves. The scope of work was therefore limited to apply only to the hill regions, where the area under wheat cultivation is relatively very small, constituting less than 5 per cent of the total. It is obvious that the former object could be achieved only if barley and any other alternate host of the wheat rusts are also taken into account as possible sources of infection: this matter is under consideration and the breeding of rust-resistant barleys is likely to be taken up soon.

The attempt to breed wheats resistant to all the three rusts is ambitious and could not have been contemplated with any considerable degree of confidence a few years ago. With the recent advances in the knowledge of the mode of inheritance of resistance to the rusts new confidence arises and the difficulties in the way of realisation of such an ideal do not appear to be insuperable. An encouraging feature is the fact that the number of physiologic races of the rusts found in India is comparatively very small (Mehta). Mehta is further of opinion that, as in Australia, the formation of new races of black rust, as a result of hybridization on barberries, occurs very rarely in this country, if at all.

In view of the complexity of the problem, the work, which is being done by the writer in collaboration with Dr. K. C. Mehta, was taken up in two stages, the first being the breeding of varieties resistant to the black, brown, and yellow rusts respectively, and the second the synthesis of further varieties embracing resistance to all the three rusts simultaneously. Preliminary tests showed that none of the indigenous varieties tested possessed much resistance to any of the rusts, with the exception of Pusa 120, which was very highly resistant to yellow rust; on the other hand a few exotic varieties were virtually immune to all the Indian physiologic races of one or the other of the three rusts, but, owing to their late maturity and other reasons, these were unsuited for direct cultivation under Indian conditions. Hybridization was therefore adopted. The segregating progenies were tested in both the seedling stage in the glasshouse and the adult stage in the field, where epiphytotics of rust were artificially created; selections were made year after year of plants combining a high degree of rust-resistance with the desired characters of grain, ear, and straw. At the time of writing, the first stage of the breeding work is nearing completion. Varieties respectively resistant to all the races of yellow and brown rust which occur in India have been built up, and varieties resistant to all the Indian races of black rust too are expected to be obtained shortly.

The stage is therefore set for the second and more arduous phase of the problem: the synthesis of varieties highly resistant to all the three rusts. A double cross has been made which, if unforeseen difficulties do not arise,

will, it is hoped, result in the production of varieties possessing the desired combinations of characters.

Breeding for smut-resistance. Next to the rusts, the most serious disease of wheat in India is loose smut, caused by *Ustilago tritici* (Pers.) Jensen. Although in the absence of accurate disease-surveys the losses occasioned by smut attack cannot be reliably assessed, there is no question that loose smut causes much damage in certain years, especially in the Punjab, Sind, and the United Provinces. Tests to discover the resistance or susceptibility of the wheat strains bred at the Imperial Agricultural Research Institute, and also of other wheat varieties which might be useful for breeding work, were begun in 1936 as a cooperative project between the Sections of Botany and Mycology (Mundkur and Pal, 1941). Unlike the position with regard to the rusts, it was found that we were fortunate in having several good wheats which possess high resistance amounting to virtual immunity in a few cases. At the same time some of the most important commercial wheats including Pusa 4, Pusa 12, Pusa 52, the Punjab strains C518 and C591, and the United Provinces strain Cawnpore 13, are highly susceptible, and further breeding work is necessary.

Another disease of wheat sometimes important in the Punjab, the North West Frontier Province, and Baluchistan, is flag smut, caused by *Urocystis tritici* Koernicke. The resistance of a large number of varieties to this fungus has been tested. Some varieties, including Pusa 4, Pusa 80-5, and Pusa 111, were found to be highly or completely resistant; unfortunately, resistance is present, in most cases, in varieties which are susceptible to loose smut.

Yet another disease of wheat, Karnal bunt, caused by *Neovossia indica* (Mitra) Mundkur, is important in some years in North-Western India, and in fact, is more serious than flag smut. For a long time the mode of infection by this disease remained obscure, but very recently this has been discovered, and it is hoped that the testing of varieties for resistance to Karnal bunt will now be possible.

Genetical and Cytological studies. Recent advances in genetics and cytology, as a result of which light has been thrown on the causes of the sterility which often attends wide crosses, will undoubtedly play an important role in the further realization of the plant-breeders' ideal of a wheat which will yield well, resist diseases and adverse conditions of growth, and produce grain of high nutritive value suitable for bread-making. Thus far only meagre use has been made of the less well-known wheat species, and of cereals and grasses of the genera allied to *Triticum* with which wheat can be induced, albeit with difficulty, to cross. Some of these are reputed to possess characters such as disease-resistance and drought-resistance which it is highly desirable to transfer to the common bread-wheat varieties. If such a transfer could be accomplished, not only would wheat growing be freed to a considerable extent from the hazards which at present attend it, but it might make possible the commercial cultivation of wheat under conditions and in altitudes and latitudes where it has hitherto been impracticable.

Physiological studies. Over the greater part of India wheat is not irrigated and the success of the crop is dependent upon the amount and the distribution of the light winter rains. The question of drought-resistance is therefore peculiarly important in India and there is a need for varieties which can give a good crop of ripe grain with a minimum quantity of water. Work has recently been started at the Institute to obtain more information regarding the complex of factors that makes for drought-resistance, and if

possible, to find an index of drought-resistance which could be employed by the plant-breeder.

It must be realised that the further improvement of Indian wheat is an arduous task for which careful planning is necessary, bearing in mind the desired characters of straw, ear, and grain, besides resistance to diseases and to adverse conditions of growth; the co-operation of the plant pathologist, the cytologist, the statistician and the plant chemist is also essential. For when plant breeding is first begun in a country in which hitherto such work has not been attempted, it is often possible to secure substantial increases in yield of 50 per cent or even more by simple selection; but after work has been in progress for some time and good varieties have been secured, it becomes increasingly difficult to obtain further large increases and the breeder has to be content with smaller, but harder-won, accomplishments. There is moreover, a tendency to judge current results in plant-breeding by previous achievements in variety improvement, and it will take time before it is recognized that the era of the old general-purpose variety is ending, and that the newer varieties will be bred to suit the special requirements of particular areas and will require intelligent handling to secure the best results.

BREEDING IN THE OUT-POLLINATING CROPS

Some important crops, for instance, maize, *Bajra*, the oleiferous *Bra-ssicae*, and vegetables, such as cabbage and cauliflower, are extensively cross-pollinated or are even almost totally selfsterile. In these, single plant selection is impossible and strains are obtained by selecting a limited number of plants as closely alike as can be found, and growing them on in isolation. The amelioration of such cultivated plants is therefore much more difficult than is the case with the self-fertilised crops, such as wheat, which we have just considered; in fact very little progress has been possible in the past and the devising of suitable methods of handling them is an urgent matter.

In self-pollinated crops natural and artificial selection has led to the development of vigorous inbred lines which had only to be isolated by the breeder after careful examination of his material. In the case of cross-pollinated plants, although it was thought that artificial selfing followed by selection would lead to similar results, extensive studies on the effects of self-fertilization with several different crop plants have shown a wide diversity of results but with a general reduction in vigour and productivity occurring as a consequence of inbreeding. These studies carried out mainly on maize and other organisms have however provided the basis for a Mendelian explanation of hybrid vigour or heterosis which usually results on crossing two inbreds and the standardization of the breeding technique, which has revolutionised maize production in America. I may here state at some length some of the main aspects of this outstanding work, carried out in America and briefly refer to the possibilities of utilizing hybrid vigour for improving other cross-pollinated crops.

The U.S.A. with the largest acreage under maize (about 90·8 million acres) naturally was the first country to be interested in maize breeding. Maize being an open-pollinated crop, mass selection and ear-to-row selection were largely practised in the beginning and varieties suited to different environments were produced. These varieties held the field for a long time until theoretical researches on genetics of the plant, initiated and carried out by Shull and East between the years 1905 and 1909 opened the way

to a new and remarkable method of breeding in this crop. These scientists discovered that inbreeding separated the highly heterozygous maize plant into a number of pure lines, that these inbreds were invariably poor in vigour and yield as compared to the original open-pollinated variety from which they were derived but that when the inbreds were crossed among themselves, vigorous F_1 hybrids far exceeding the yield of the original variety were produced. Based on these findings, maize breeding programmes involving the hybridization of inbred lines were initiated at several of the agricultural experiment stations in the country for production of F_1 hybrids or what are known as single crosses. But the greatest advance came about the year 1920 when Jones showed that the double cross (cross between two single crosses) was a practical means of obviating certain inherent difficulties associated with large-scale production of single crossed seeds. The inbreds being usually very poor yielders, the single crosses gave very little seed for distribution on a large scale; further the single crossed seeds were genetically similar and on that account were less adaptable and more susceptible to injury by adverse growing conditions at critical periods. On the other hand, in double crosses both the seed and pollen parents were vigorous and productive and therefore more seed could be obtained. Double crossed seeds being genetically more variable were more adaptable and less susceptible to adverse conditions of growth.

About the year 1925-26 several thousand inbreds were put to yield tests in cross combinations and commercial hybrids were distributed for the different localities. From the year 1922 when the first hybrid corn was distributed, to the year 1939, the area under hybrid maize increased to well over 20 million acres. The yield increases obtained by the use of the hybrids are reported to be up to 40% and more over the standard varieties. In addition to giving greater yields, the hybrids were found to be uniform and more able to withstand drought, wind, disease and other unfavourable conditions than the best open-pollinated varieties.

Side by side with the practical utilization of hybrid vigour for increased production, researches on the theoretical aspects of this phenomenon have also been in progress and as a result of the knowledge gained, further modification in the actual methods, directed to economising on labour and time, were introduced. Thus the top-cross, three-way cross and the multiple cross came into being. It must, however, be mentioned that after about thirty years of research, the geneticists have not fully understood the principles involved in the phenomenon of hybrid vigour. The location of the genes involved and their mode of operation are still unsolved problems engaging the attention of several scientists, for on a complete solution of these will depend further progress in maize breeding.

In India no serious attempts have so far been made to exploit commercially hybrid vigour in maize although such attempts have been made in countries other than U.S.A. with encouraging results. As far back as 1926, a hybrid maize breeding programme was started in Queensland and several hybrid combinations have been produced giving yield increases of 20% and more than the controls in different localities. Tests in Rhodesia which started about 10 years ago, have shown that some of the hybrids produced in that country are capable of giving 20 to 30 per cent more yield than the standard varieties. In India, attempts to improve maize have been confined either to acclimatization of exotic varieties or to mass selection from local types. These methods have naturally not given very encouraging results. At the Imperial Agricultural Research Institute, New Delhi, however, a small collection of maize varieties was grown and a number of inbred strains

selected some years ago. In a small-scale test these inbred strains were found to show conspicuous vigour in the F_1 generation.

Besides maize there are several other crops e.g., tomatoes, tobacco, egg plants, etc., where because of the facility with which crossed seeds can be produced, the agricultural utilization of hybrid vigour is possible. Researches carried out at the Imperial Agricultural Research Institute on tobacco and egg plants show that a high degree of hybrid vigour is manifested in certain crosses. One particular cross in the eggplant has already achieved a considerable measure of success.

The oleiferous *Brassicæ* constitute another important group of cross-pollinated plants; some of its species are even totally self-sterile. Breeding in these crops, in India, has so far been mainly by mass selection. Extensive researches are now in progress at the Institute under my colleague Dr. S. Ramanujam which are directed towards the study of the inheritance of self-sterility; the isolation of self-fertile genes and the desirability of adding them to improved strains, the effects of controlled inbreeding and polyploidy for the formulation of better and more suitable methods of breeding in this difficult group of crops.

BREEDING IN THE VEGETATIVELY-PROPAGATED PLANTS

Many crop plants are vegetatively propagated by tubers (e.g., potatoes), cuttings (e.g., black currants), grafts and buds (e.g., fruits, etc.), runners i.e. stolons (e.g., strawberries) and so on. Special possibilities, denied in seed-grown crops, are open here. Thus bud-mutations can be immediately propagated, and in certain citrus fruits much improvement has been achieved in this way.

BREEDING GRASSES AND FORAGE CROPS

In many crop plants much less has been accomplished in crop improvement than with such major crop plants as wheat, rice and cotton. This applies particularly to the grasses, where studies of improvement have not progressed very far. The methods of breeding grasses and forage crops have not yet been standardised; in fact the necessary knowledge for such standardization is not yet available. It is also certain that not all grasses can be handled by the same method, and suitable techniques have to be developed for different grasses.

Considerable attention is now being paid to grass improvement in Wales, Sweden and Canada. But in many other countries, the position is not so favourable. In India, even a start has hardly been made, at any rate as far as breeding is concerned.

THE IMPROVEMENT OF VEGETABLES

The breeding of vegetables presents problems of its own. In India, vegetables may be divided into two groups: (1) the so-called European vegetables, such as the cabbages, cauliflower, carrot, beet-root, tomato, etc. Many of these are self-sterile and require a cool climate for satisfactory setting of seed. Others like the tomato are easily handled because they are self-fertile and can easily be grown and made to produce seed even in the hot plains. (2) The so-called *desi* vegetables, such as the eggplant, okra, pumpkin, bottle-gourd, etc. In a country which is to a large extent vegetarian, a good supply of nutritious vegetables is of unusual importance: so far, however, only the Punjab has a full-time vegetable specialist and the breeding of vegetables for Indian conditions is yet in its infancy.

THE IMPROVEMENT OF FRUITS

Joshi (1943) has remarked: "The cultivation of fruit trees and horticultural practice in our country is still at a very backward stage. It is no exaggeration if one says that so far in this country absolutely no attempt has been made to breed better varieties of fruit trees on modern scientific lines. If there are some good varieties of fruit, for instance, those of mango, in some parts of the country, it is entirely due to the keen insight and wisdom of some of our perhaps remote ancestors who introduced them, rather than to any effort on our part. . . . Many species of plants with edible fruits grow wild in the Himalayas. There is, for example, the Kaphal or Kaiphal, the fruit of *Myrica Nagi* Thunb. It has at many places a fine taste but rather too little flesh as compared with the stone. Then there are *Hinsalu* and *Kalahinsalu*, the fruits of *Rubus ellipticus* Smith and *R. lasiocarpus* Smith respectively. They only suffer from too many small seeds. All just need the attention of a plant breeder to give us new fruits of good quality."

No one will disagree with this conclusion and it is hoped that the vast opportunities which lie in the field of fruit improvement will be speedily made use of.

THE IMPROVEMENT OF TREES

Trees are important sources of fuel, of timber, and of other products, such as gums, resins, latex, dyes, etc. An adequate cover of forest and grass is also the best protection we have against soil erosion. Go-ahead countries like Russia and Sweden have realized the importance of applying modern methods of breeding to forest trees, and have completed surveys of the forest resources available in their countries. Triploid aspens and other trees with twice the growth rate of the neighbouring diploid trees have been obtained. Newer methods of propagation and grafting are also under investigation. It is hoped that work on these lines will also be taken up in India.

Randhawa (1945) has drawn attention to the neglect of our beautiful flowering trees. Many charming varieties already exist which should be propagated extensively and many more could be produced by breeding, to beautify our land.

The brief notes given above will give some indication of the many and important ways in which plant breeding can aid human welfare in India. I cannot do better in concluding this Section than to quote the following words of Darlington (1944) :

"There are great areas of jungle and desert in India which are uncultivated because no one has yet found a crop suitable for them. In order to utilise these vast expanses of waste land, it is our business, if we cannot find a suitable crop ready to hand, to make a new one. And if millions of Indians suffer from malaria it is not enough to say that *Cinchona* will not flourish in India. New types must be found, and new hybrids raised, which will flourish. Great areas of Russia, Sweden and Canada, have been brought under cultivation by making new plants to suit them. New frost-resistant apples, new hardy rye-wheat hybrids, new drought-resistant or sand-binding grasses, new forest trees have been bred for that purpose. What has been done for the arctic desert can also be done for the tropical desert."

PLANT PROTECTION

Ever since the dawn of recorded history, plant diseases and pests have been among the greatest hazards in the production of crop plants, and they

still are. Whetzel (quoted by Stakman 1937) has said : "One bean in every dozen, one apple in every seven, one peach in every eight, one bushel of Irish potatoes in every twelve, and one bushel of wheat in every ten, are destroyed annually by diseases in these crops." To realize the tragic consequences of such crop catastrophes to farmers, and indeed sometimes to the whole nation we have only to recall the great potato famine in Ireland in 1845 caused by Late Blight. Nearer home we have heard of the destruction of the coffee industry of Ceylon and Java by leaf rust.

It is not only fungi and bacteria that cause such devastating losses ; the plant viruses are exceedingly important agents of destruction in many cultivated plants. Then again insects are of very great importance not only because of the damage they themselves actually do by biting or sucking various parts of the plant or by attacking the fruit or grain, but they are tremendously important in spreading plant diseases. Indeed in the case of some plant pathogens, they are the principal or only agents of dissemination and inoculation.

Plant pathologists and entomologists have done service by devising sprays and dusts to control diseases and pests, and in promoting quarantine measures to prevent the spread of dangerous disease-causing pathogens and insects. It is universally admitted however that the ideal solution of the disease problem is the evolution of resistant varieties : this solution is of paramount importance in a country like India where the average farmer is too poor to be able to afford the cost of spraying and dusting.

The record of breeding disease and pest-resistant strains of economic plants is one of which botanists may well be proud. In the brief space at my disposal I can only mention the breeding of the rust-resistant Hope, Ceres and Thatcher wheats in the U.S.A., the virus-resistant Craigs' Defiance potato in Scotland, jassid-resistant strains of cotton in Africa, and in our own country, wilt-resistant cottons in Bombay and wilt-resistant pigeon-peas at Pusa.

It must be realised however that superior varieties are not produced by the working of a magic wand : they are the result of long and painstaking breeding and testing. "The breeding of disease-resistant varieties is not a pastime for botanists in their spare moments." It requires time, labour, skill and adequate facilities, and team-work between plant breeders, plant pathologists and entomologists.

PLANT PHYSIOLOGY

Vernalization. A remarkable development in this field of research in recent years, which is of considerable significance to breeding, is the theory of vernalization developed by Lysenko. It has been shown by him that through vernalization the time of flowering of any variety of plant can be experimentally predetermined by appropriate treatment of the germinating seeds. "According to Lysenko, plant growth and plant development are two distinct and separate phenomena each of which is capable of proceeding independently of the other." At least two stages are recognised by him in the development of a plant, the first one being the thermo stage and the second the photo stage. Particular temperature conditions are required for completion of the first stage and certain light conditions for the second stage. If these conditions are provided to the germinating seed in appropriate amounts, the plant is in a condition to pass on to the reproductive phase without further recourse to temperature or light. Every variety has its own particular requirements with regard to temperature and light and these will have to be

determined experimentally for successful treatment. The advantage of vernalization has been made use of chiefly in Russia for extending the cultivation of wheat farther north where the growing season for wheat is very short. Vernalization has also been studied in other countries and the responses of different crop varieties are being tested. It has been found that vernalization responses are more complex than originally postulated by Lysenko (Purvis 1934, Purvis and Gregory, 1937) and the different phases of development are by no means as sharply differentiated as he assumed, but the fact that the time of flowering could be modified experimentally has been confirmed.

In India vernalization would be of value only in the regions where special conditions prevail which render the growing of crops a precarious operation. The direct application of vernalization to agriculture does not appear to hold much promise particularly because the earlier maturity induced by vernalization has given indications of decrease in yields. Vernalization however is of great value in the speeding up of plant breeding. It would thus be possible to adjust the time of flowering in genetical work. Vernalization also facilitates the rapid multiplication of desirable strains by making it possible to grow two or more generations in an year. Besides these advantages vernalization has a direct genetical application in the production of early-maturing forms, as has been shown by the Russian scientists: crosses of varieties with two different requirements for the progress of their developmental phases usually transgress the parental limits in respect of early maturity, if these requirements are complementary to one another.

Growth Hormones. Closely associated with this study of experimental control of the time of flowering of plants, is the study of the chemical control of growth and development in plants. Perhaps the most interesting chemical modification of plant development is that caused by organic substances of the hormone type.

It is becoming increasingly evident that certain specific chemical regulators (hormones) are responsible for causing tropic responses of plant organs to light and gravity, inducing cell elongation and root growth and also initiating and regulating growth of buds and flowers. Purvis and Gregory (1937) in a theoretical interpretation of their result of vernalization with winter ryes assume the existence of variable interactions between specific foliar and floral inductors. Muntzing (1938) cites another interesting case of modification of flowering due to a specific substance. There occur annual as well as biennial races of *Hyoscyamus niger*, this difference being caused by a single gene. However by grafting shoots of an annual plant on a biennial one, it has been possible to induce the latter to flower as an annual. Some of the organic substances (auxins) that initiate root formation are being extensively studied and used for propagating cuttings with great success (Tincker 1936). Recent work has shown that certain of these chemicals can also induce early flowering and promote seed setting in plants. This new field of research is full of possibilities for the future.

Hydroponics. Another field of research which has come to the front in recent years is hydroponics. From the time Liebig started his classical studies of plants in water and sand cultures, this technique was being widely used for experimental purposes. But in the year 1929 Gericke demonstrated that "crop production need no longer be chained to the soil, that some commercial crops could be grown in large quantities without soil in basins containing solutions of plant food."

Besides the novelty of the principle of growing crops without soil, some

of the results obtained by this method are astounding, the yields being far superior to those obtained from the richest of farm lands. Hydroponics however does not give promise of immediate application to agriculture because it presents a number of problems, such as supplying the nutrient elements through a well balanced solution, giving the crop a uniform and adequate amount of light and heat and proper spacing of the plants, which require thorough investigation before the method can be made an economic proposition.

There are also other fields of Botany wherein material contributions have been made to human welfare. But lack of space does not permit me to touch upon these, and I think enough has been said to show how important a proper study and application of botanical methods can be.

CONCLUSION

The present century has seen an astounding development of botany. "Once upon a time it was *scientia amabilis*, the lovable science, eminently suitable for leisured amateurs. It has now grown into a galaxy of sciences each in itself a new world" (Burns and Pal, 1942). We have seen, although in a fragmentary and incoherent manner, how this group of sciences can serve mankind. But as I said at the beginning of this address, we must provide for well-rounded, liberally-supported research to be carried out over a long period of years.

When so little has yet been achieved, and so much remains to be done, help and encouragement must be given to all the sciences we have been concerned with. But I should like to take this opportunity to stress the need for greatly increased attention to genetics, the science basic to modern plant breeding. Born only at the beginning of this century, this science has progressed rapidly and is being hailed elsewhere as the science of the future with untold possibilities for the improvement of both animals and plants. As Burns (1943) has remarked, "Some understanding of genetics ought to be part of the education of any human being whose training goes beyond that of the secondary school." Yet the teaching of this important subject is neglected, and in India not a single university has a chair of genetics. Ramanujam (1944) has shown how genetics can be applied to agriculture and emphasised the need of ensuring that it receives its proper place in any scheme of scientific development.

It has been remarked that the price of a sound, comprehensive national life in these times is widespread and intelligent scientific research. In this research botany has a very important part to play.

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SECTION OF ZOOLOGY AND ENTOMOLOGY

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DEVELOPMENT OF KIDNEY IN FISHES

(Delivered on 5th January, 1946)

Allow me to express my gratitude to the authorities of the Indian Science Congress for electing me President of this Section. I request your co-operation in making the meeting of this Section a success.

The ancestral craniate was probably provided with a complete set of "segmental bodies" extending over the whole of the trunk region. These opened into a longitudinal duct extending to a posterior cloaca. In the existing craniates a few anterior tubules and their duct develop first. A second set of a larger number of tubules succeeds the first in more posterior segments and these also open into the duct of the former tubules. This second set is succeeded in reptiles, birds and mammals by a third set of more posterior tubules which form the adult kidney. Thus according to Lankester (1877), an original complete archinephros with its duct differentiates into pro-, meso-, and meta-nephros.

Sedgwick (1881) held the view that the pro-, meso- and meta-nephros were merely successive parts of a single elongated ancestral excretory organ which possessed a duct and segmentally arranged nephridial tubules.

Each tubule develops directly or indirectly from the nephrotome before it separates from the somite. Its cavity persists as the peritoneal funnel. At the other end the tubule opens into a longitudinal duct (pronephric duct, archinephric duct, segmental duct) which is also purely of mesodermal origin, though its exact mode of development is still in dispute.

While the above serves as a general description of the development of kidney in the craniate, there are individual differences in the various classes. I propose, in this address, to give a brief account of the development of kidney in fishes.

ELASMOBRANCHII

Balfour (1874) and Semper (1874, 1875) have described the development of kidney in this group of fishes. Semper's description is influenced by the belief that the excretory organs of vertebrates are of the same nature as the nephridial tubes of Annelida except that in the latter each opens separately to the outside.

According to Balfour (1874, 1876, 1878), the first trace of the system is in the form of a knob of mesoblast arising from the intermediate cell mass near the level of the hind end of the heart. This knob is the rudiment of the abdominal opening of the segmental duct and from there grows posteriorly to the level of the anus a solid column of cells which constitutes the Anlage of the segmental duct itself. The knob and the column acquire a lumen. The lumen of the knob communicates with the body cavity,

Balfour considers this knob to be the only structure which represents the pronephros of other fishes.

While the lumen is being formed, the segmental tubules of the mesonephros make their appearance as differentiations from the parts of the primitive lateral plates of mesoblast viz. the intermediate cell masses. The lumen of each tube opens at its lower end into the dorsal part of the body cavity. There is a segmental tube for each somite. The first one is immediately behind the abdominal opening of the segmental duct, the last one a few segments behind the anus. The blind ends of the segmental tubes open into the archinephric duct. Each segmental tubule has a peritoneal funnel opening into a dilated vesicle, a coiled tubulus from the vesicle opening in the segmental duct.

The segmental duct soon retires from its primitive position between the epiblast and mesoblast and comes to lie close to the epithelium lining the body cavity.

The subsequent important change in the segmental tubule consists in the formation of a small bud from the vesicle near the peritoneal funnel. This bud joins the coiled tubulus close to its opening into the segmental duct (now called the Wolffian duct). The remainder of the vesicle becomes converted into a malpighian body. Thus a tube is established connecting each pair of segments of the mesonephros. This tube is later represented by only a fibrous band. But the secondary and tertiary malpighian bodies are developed from its persisting blind end. Each of these malpighian bodies is connected with a convoluted tubulus which is also developed from the tube connecting each pair of segmental tubes and therefore falls into the primary tubulus close to its junction with the segmental duct. Accessory tubuli now develop and the segments of mesonephros assume a compound character.

The portion called the coiled tubulus of each mesonephric tubule grows and becomes convoluted. Each tubule now shows the following parts : (1) an oval peritoneal funnel which leads directly into (2) a narrow tube which opens into a malpighian body at the anterior extremity of (3) a coiled tubulus. The latter shows accessory malpighian bodies and finally opens by (4) a narrow collecting tubule into the Wolffian duct. Each segment is complete in itself. But soon the collecting tubuli of the hinder segments (10 or 11 in *Scyllium*) elongate or overlap and eventually open by apertures, less in number than the separate tubes into the hinder portion of the Wolffian duct in the female or into the urogenital cloaca in the male; or, they become modified by a peculiar process of splitting from the Wolffian duct, so as to open into a single duct on each side which opens in a position corresponding to the numerous ducts of other species. The modified posterior tubules form the adult kidney which is probably of the same nature as the metanephros of the higher craniates. The anterior of the early mesonephric tubules retain their connection with the Wolffian duct and form the mesonephros.

While the foregoing account given by Balfour is correct, it has been supplemented in one respect by Rabl (1896) and Bates (1914). The "knob" is not the only representative of the pronephros. The pronephric chamber appears in embryos possessing 20 to 25 somites. It is a thickening of the somatic layer of the intermediate mass extending from three to eight segments (the number in different animals is variable). All the thickenings which are segmentally arranged show the form of a pad in which there are nephrocoelic openings. But a little later the whole of this structure atrophies.

No glomeruli develop; only segmentally arranged branches of the dorsal aorta appear corresponding in number to the pronephric tubules.

A review of literature on the question of the formation of the pronephric duct in Elasmobranchii reveals that there are two sharply contrasting views about its formation. According to van Wijhe (1886, 1888) in *Raja clavata* and Ruckert (1888) in *Torpedo*, the archinephric duct makes its appearance from a longitudinal ridge like projection inwards from the ectoderm and splits off as a solid ectodermal rod which develops a lumen. C. Rabl (1896), Bates (1914) and others, on the contrary, decline to accept the ectodermal origin of the duct. They maintain that the duct splits off from the underlying mesoderm.

A very detailed account of the development of kidney in elasmobranchs based on a study of the development of this organ in several species is given by Borcea (1906). It confirms the account already given.

DIPNOI

Wilson (1901) gave a preliminary account of the development of excretory organs in *Ceratodus*. Since then, the development in all the three species has been described.

In the larvae of *Lepidosiren* and *Protopterus*, there are probably four pronephric tubules belonging to segments 4 to 7. Each tubule arises as a solid outgrowth from the nephrotome from which the archinephric duct also arises. Probably two of these viz. those belonging to segments 4 and 6 do not complete their development. The fully formed pronephros possesses usually two tubules.

The nephrocœles of the two surviving tubules undergo fusion so as to form a large pronephric chamber on each side. The glomerulus of each tubule also fuses and thus a large compound glomerulus is formed.

In *Lepidosiren*, the glomerular rudiment appears on the floor of the pronephric chamber but later shifts by growth towards the dorsal mesial plane and hangs down in the pronephric chamber.

The pronephric chamber is in communication with the splanchnocœle. This latter spreads outwards. Later the pronephric chamber becomes greatly enlarged and bulges across the splanchnocœle and comes into contact with the mesodermal sheath of the oesophagus. Later the glomerulus comes to be enclosed in a secondary pronephric chamber, which opens into the splanchnocœle at its posterior end.

According to Semon (1901), the pronephros of *Ceratodus* also appears as a solid projection of the mesoderm as in *Lepidosiren* and *Protopterus*. The fully formed pronephros consists of two tubules only. Kerr thinks that "these are the survivors of a once greater number, though there is no record of other rudiments having been actually observed". Greil (1908) actually observed four tubules in two specimens of *Ceratodus* (stage 34).

According to Kerr, the development of mesonephros closely resembles that in Amphibia. In *Lepidosiren* and *Protopterus* the tubules of mesonephros appear as rounded solid masses. In *Protopterus*, they appear about segments 14—18 as condensations of mesenchyme extending right forwards as far as the hind limit of the pronephros, and posteriorly up to the 36th segment, about one segment anterior to the cloaca. These tubules are segmental in position. Each rudiment gives rise to a tubule with a malpighian body. The tubule opens into the archinephric duct (Wolffian duct). No peritoneal canals seem to develop though they are temporarily present in *Ceratodus*.

The origin of secondary mesonephric tubules has not been worked out.

CHONDROSTHEI

ACIPENSER

The earliest account of the development of head kidney and the archinephric duct is given by Kowalevsky, Owsjannikov and Wagner (1869). They refer to the first appearance of the archinephric duct and state that later it divides at its anterior end at first into two and later into three branches. These are probably pronephric tubules.

Jungersen (1893) states that the pronephros in *Acipenser sturio* consists of six ciliated funnels, the first opening into the body cavity, the five hinder ones communicating with a closed chamber lying below the aorta and containing a long glomerulus. A narrow ciliated canal runs transversely from each funnel to the coiled anterior portion of the duct. At a later stage of development the anterior funnel which opened into the body cavity closes, the second also disappears in some specimens. Only four funnels are left. The mode of origin of these structures has not been described.

Pavlenko (1916) published a preliminary note on the development of head kidney in *Acipenser ruthenus*. Maschkowzeff (1924) gave a brief account of the development and this was followed (1926) by a more detailed account. Dr. E. A. Fraser (1927) gave a detailed account of the development of the pronephros of the sturgeon, *Acipenser rubicundus*. According to her, at 51 hours after fertilisation, the primordium of the pronephros appears as a solid block of cells separated by a groove from the somite on one side and the lateral mesoderm on the other, both somite and mesoderm being solid. In the next older embryo 76 hours after fertilisation, there are already six pronephric canals, the first five arising from a series of nephrotomes lying opposite to somites IV to VIII, to the dorsolateral sides of which they are still attached. The sixth canal is connected by a solid mass of cells with somite ninth, no nephrotome having as yet developed. The first nephrocoele continues forwards into the general coelom of the head region whilst those of the two following communicate by a narrow canal with the splanchnocoel; behind this level the lateral mesoderm is solid. Pronephric canals are short and each runs into the excretory duct, the two ducts passing back to open close together into a groove on the ventral side of the body. The pronephric canals all arose before the nephrotomes developed.

The nephrotomes have a different history. The first one is a part of the general body cavity into which it opens by a large funnel. This funnel becomes external nephrotome I of the fully developed pronephros. Nephrotomes V to X form a series of six pronephric chambers lying one behind the other. As soon as the splanchnocoel develops, nephrotomes V and VI and VII, VIII communicate with it. In older embryos, the nephrotomes separate off from the body cavity. The pronephric chambers become completely shut off from the body cavity. Walls between adjacent chambers break down so that there is one long chamber.

The fully developed pronephros has thus one large external nephrotome and five or six internal ones on each side, the latter opening into an elongated pronephric chamber on which lies an internal glomus. The pronephric duct into which the canals open expands into a large vesicle. The pronephros degenerates.

The details of the formation of the pronephric duct have been given by Maschkowzeff (1926). The primordium of the duct arises as a thickening which rises up from the dorsal side of the mesoderm between the somite and lateral plate, the mesoderm being solid. Towards the hinder portion of the

primordium, the thickening is sharply marked off from the underlying mesoderm, and forms a definite fold which becomes the archinephric duct.

At the level of somite XVI, the anterior part of the mesonephros begins as small, darkly staining clumps of cells on the inner side of the duct. These acquire a lumen and become definite tubules. The earlier account of Jungersten is not very detailed.

There is an intermediate region between pro- and meso-nephros where vestigial tubules appear but take no part in the formation of the kidney.

The functional pronephros of *Acipenser* is better developed and more primitive than in other ganoids or than in *Polypterus*. It possesses a larger number of tubules. Fusion of the chambers is more extensive than in any other vertebrate, the long pronephric chamber being made up of 9—10 nephrotomes.

POLYPTERUS

According to Kerr (1907) seven to nine segmentally arranged pronephric rudiments arise from the nephrotomes. These rudiments fuse at their outer ends to form a solid mass which is the rudiment of the archinephric duct. Some of the tubule rudiments become reduced in size and atrophy. Those belonging to nephrotomes II and V increase in size and become functional tubules. The solid rudiment of the archinephric duct acquires a lumen. The nephrocoeles belonging to the various nephrotomes form a series of closed cavities one behind the other. These are widely open coelomic spaces. Two of these viz. those which are connected with the two functional tubules (B and E) become increasingly dilated. A glomerulus appears on its floor. The cavity is continued vertically and eventually opens into the splanchnocoel. The floors of the original nephrocoeles become folded in towards one another and the glomeruli are eventually borne on the mesentery on each side.

The two functional nephrocoeles and their glomeruli become continuous. Peritoneal canals are not formed between nephrocoeles and splanchnocoel.

According to Kerr (1907), the hinder portion of the archinephric duct appears to be formed by the bodily conversion of nephrotomes. These are segmented but form a continuous structure which becomes converted into the archinephric duct.

The mesonephros appears in the form of rounded cell masses arranged segmentally in the mesenchyme ventral to the myotomes. Each of these acquires a lumen. Each elongates to form a thick curved mass.

HOLOSTEI

LEPIDOSTEUS

Müller (1844) and Hyrtle (1854) described the development of kidney in this animal but a very detailed account was given by Balfour and Parker (1882). According to the latter authors the first portion to be formed is the segmental duct as a hollow ridge-like invagination of the somatic layer of the mesoblast. The cavity of the ridge communicates with the body cavity. In an embryo 10 mm. in length this becomes dilated. The anterior end opens in a pronephric chamber which is later cut off from the body cavity except for a richly ciliated passage leading from the body cavity into the pronephros on each side. The pronephric chamber soon becomes filled by a vascular glomerulus. The pronephros increases in size by the further convolution of the duct.

Beard (1889, 1895) considers that there are three outer and three inner funnels. The former open into the body cavity and the three inner, as in

Acipenser and *Amia* open into a capsule which represents a completely shut off portion of the body cavity. Into the capsule, there projects from the underside of the aorta a long folded glomerulus. At a later stage, the outer and inner funnels become reduced to two on each side. Thus the pronephros of *Lepidosteus* hints at a condition found late in the development of *Acipenser* (Jungersen, 1894).

The mesonephros is formed some distance behind, and some time after the pronephros. At its first appearance it has the form of segmental nephridial tubes which later become continuous (Balfour and Parker, 1882). Beard (1895) states that the mesonephros arises between the 16th and 18th day. Its tubes are formed in the angle of the body cavity between the region of the segmental duct and the genital ridge. But Beard considers that the mesonephros can neither be derived from any part connecting the somites and the body cavity nor from any part of the somites. There is here no intermediate cell mass but the mesonephric tubules arise as distinct segmental ducts of the wall of the body cavity. They grow over the segmental duct in a curved fashion and open into it by piercing through its walls.

AMIA

Jungersen (1894) described the development of pro- and meso-nephros in *Amia* from observations made on three larvae 7 to 18 mm. in length. In his youngest larva (7—7½ mm), the excretory organ consists only of the archinephric duct without any rudiment of the pronephric tubules. The archinephric duct runs a straight course to the hinder end and unites with its fellow of the opposite side before it opens to the exterior. In a 10 mm. larva he finds that the pronephros is well formed and it has an inner and an outer ciliated canal. The inner one is in relation to a large glomerulus. The archinephric duct anteriorly becomes more coiled.

In this stage he also finds the first rudiments of the mesonephros. They appear at about 16—17 segments and the rudiments are segmentally arranged. I find that both from the above description of Jungersen and that of Felix (1906) there is only a *single* functional tubule. Possibly the large pronephric chamber into which the tube opens may be formed by the fusion of at least three nephrocoeles belonging to three pronephric rudiments or even more.

TELEOSTEI

Considerable amount of work has been done on the development of pronephros in *Teleostei*. Even a short historical summary would occupy several pages. The principal accounts are by Burnett (1854), Rosenberg (1867), Oellacher (1873), Romiti (1874), Goette (1875), Semper (1875), Fürbringer (1878), Nussbaum (1878), Emery (1878), Ziegler (1882), Ryder (1882), McIntosh and Prince (1887), Brook (1887), Henneguy (1888), Wilson (1891), Sabotta (1894 a and b), Felix (1897), Swaen and Brachet (1899, 1902), Ströer (1930). I very much regret that my work on the development of pronephros in some species of Nagpur fishes is still unpublished.

Of the foregoing, four contributions are worth consideration. Rosenberg's account (1867) is regarded as a pioneer piece of careful investigation. The Anlage of the excretory system in *Pike* is the primary urinary duct on either side of the body and is formed from the somatic layer of the mesoderm. Each duct, at first solid, later acquires a lumen and each duct opens at both ends into the body cavity. Anteriorly the duct elongates and coils. The terminal portion is invaginated by the glomerulus.

Felix (1897) describes the development of the kidney in the *Salmonidae*.

According to him the head kidney (Vorniere) consists of many transverse and segmental tubules. Each tubule may begin with a peritoneal funnel opening into the body cavity or may be cut off from it. The tubules are connected with the anterior portion of the archinephric duct by collecting tubules and posteriorly the archinephric duct opens *into the intestine* or independently of the intestine to the exterior. The head kidney tubules arise as bulgings from the body cavity prior to the formation of the duct. Kerr (1919) bases the account of the development of pronephros on the views and findings of Felix. There are at least *five* rudiments which are soon indistinguishable and form a pronephric fold. It forms a pronephric chamber.

It is surprising that Kerr (1919) pays no attention to the excellent work of Swaen and Brachet (1899 *et* 1902) which is so well summarised by Brachet (1935). Swaen and Brachet consider that in an embryo possessing thirteen somites, the archinephric duct is very distinct from the fourth to tenth somite. In an embryo with eighteen somites the canal extends posteriorly up to the 16th and still later up to the 19th. The anterior part of the canal forms the various parts of the pronephros. The pronephric chamber is also a differentiation of the anterior part of the duct. It is evident from this description that the pronephric chamber and the excretory canal have the same origin. Also the cavity of these is morphologically equivalent to the body cavity and that the pronephric chamber gives rise to the *single* pronephric tubule and collecting canal and is not, as Felix asserted, formed by the union of five rudimentary pronephric tubules.

Swaen and Brachet in a subsequent paper (1902) extended their observations to other fishes and confirmed their earlier views. The extent of the pronephric chamber varies in different species. The observations of Swaen and Brachet were confirmed by Ströer (1930). He asserts that the development of pronephros in *Perca fluviatilis* follows the same general lines as in the Trout described by Swaen and Brachet. In the very early stage investigated by him (age 12 days, embryo not hatched), the excretory apparatus is in the form of a pronephric tubule with glomerulus at one end and the other end continuous with the archinephric duct.

From the foregoing resumé of the views held by various authors on the development of pronephros in *Teleostei*, it is obvious that there are two sharply contrasted views, viz.—

1. The archinephric duct develops first. Its anterior end differentiates into a pronephric tubule with an invagination for glomerulus. This tubule differentiates into a pronephric tubule which is coiled in later stages and a collecting tubule (*le collet*) which opens into the archinephric duct.
2. The pronephric tubule develops independently of the archinephric duct but later opens into it.

It may be mentioned here that Felix considers that the early rudiments of the pronephros are *five* segmentally arranged projections from the lateral mesoderm towards the mesial plane. Others consider that there is only a single pronephric tubule in the *Teleostei*.

There is also a certain amount of controversy regarding the origin of the archinephric duct. McIntosh and Prince (1887) and Brook (1887) attributed an ectodermal origin to the duct. But it is now generally proved that the duct is mesodermal in origin.

The development of mesonephros in teleostean fishes has been studied by a large number of workers among whom may be mentioned Rosenberg (1875), Goette (1875), Fürbringer (1878), Nussbaum (1878), Emory (1882),

Hoffmann (1886), Felix (1897) and Maschkowzeff (1934). Recently I have published a paper on the subject. Both Brachet (1935) and Kerr (1919) base their account of the development of mesonephros entirely on the researches of Felix (1897). Felix derives the mesonephric tubules, in the first instance, from solid aggregates of cells formed by proliferation from *the wall of the archinephric duct*—a view earlier put forth by Nussbaum (1878). Further, according to Felix, these tubules are replaced by the tubules of the permanent mesonephros formed from cells of unknown origin. If this account of the formation of temporary mesonephric tubules from the wall of the archinephric duct is true, it is evident that this is the only group among vertebrates in which such an origin of the mesonephros takes place. Further, it should be possible to trace the cells forming the permanent mesonephric tubules to some embryonic source. Maschkowzeff (1934) traced the origin of the mesonephric mesenchyme to the 'intermediate cell mass'. It is not, however, clear whether he accepts Felix's theory of the existence of a temporary and permanent mesonephros.

For some years, I was engaged on investigating the development of mesonephros in teleostean fishes. My results can be briefly summarised :

In early larvae (4 mm to 6 mm), almost every section of the body through the mesonephric region shows that there is a bridge of deeply staining cells on the dorsal side of the archinephric duct and extending from the duct of one side to the other between the aorta and the cardinal vein. These cells are called "Bridge" cells. This is the 'nephrogenetic mesenchyme' or 'blastema' as termed by Hall (1904). Even in these early stages, some of these cells have accumulated together to form solid condensations. These occur segmentally from the tenth segment posteriorly. They are not always at the same stage of development. The number of these condensations increase and in older larvae (7 mm, 8 mm) one can see segmental condensations very near the archinephric duct. It is this proximity which must have led Felix to derive the rudiments of mesonephric tubules from the archinephric duct.

The source of the "Bridge" cells (Emery, 1882) can be easily determined. Before the lateral mesoderm has separated from the myotome, an intermediate cell mass or nephrotome would lie at the base of the myotome. These "Bridge" cells are formed from the intermediate cell mass.

In these stages, one can also see that these mesonephric condensations have developed into tubules. In my paper referred to in the bibliography I have reconstructed some tubules and given the details about their relation to the glomeruli.

Secondary and tertiary tubules are also formed from similar cells which condense to form blastemata. These later become tubules and develop glomeruli.

I was able to establish that the rudiment of a mesonephric tubule is represented by the mass of cells between the myotome and the lateral plate. I do not get anything like a solid outgrowth as described by Maschkowzeff (1934) but instead there is a mass of cells which later condenses to form aggregates.

In all Anamniota and Amniota, the mesonephros arises in this manner. Owing to the acceptance of Felix's view, the teleostei seemed peculiar inasmuch as the mesonephric rudiment arose from the archinephric duct. But I was able to show that this view is not correct and even in teleostei the mesonephric rudiment arises from the intermediate cell mass,

Within the limits of this address, it is not possible for me to enter into details. I am conscious of the various acts of omission. I should have liked to discuss the terminology of the various parts: myotome, lateral plates etc. and the validity of the term nephrotome. I should be content to refer the reader for these and for various details to Prof. Goodrich's excellent book (1930) and the copious bibliography given by Prof. Goodrich (1930) and Bashford Dean (1916).

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SECTION OF ANTHROPOLOGY AND ARCHÆAEOLOGY

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ARCHAEOLOGICAL PLANNING FOR INDIA : SOME OF THE FACTORS

(*Delivered on 3rd January, 1946*)

A congress of scientists such as that which has brought us together in this room to-day has diverse duties and uses. It is a focus of academic gossip, a bazaar of ideas and aspirations, a shop-window of recent achievement. But if it is to fulfil its task worthily, it is at the same time something more than that. It is above all a representative planning committee. To-day, the world is full of planning committees. Few of the many plans will achieve actuality, and, of those that do, fewer can be expected to achieve their real intention. Let us not on that account cease to plan. A mountain which produces only a mouse is livelier than a mountain which produces nothing at all.

I ask therefore that for the next three-quarters of an hour we indulge in a little serious planning. The other day I had occasion to remark to a committee of the Central Legislature that, as an archaeologist, I was concerned with the future rather than with the past. I was gently corrected, but my words were correct. In India, Archaeology and Anthropology have admittedly little enough behind them. There have been archaeologists and anthropologists in this country, but no coherent *science* of archaeology and anthropology has ever been established here, such as has been partially established in western Asia, in Europe and in America or such as was growing up in China before the barbarous devastation of that country in the name of progress. Indian humanistic science has been relegated largely to the future. But the future of India is now close upon us. It is time not only to plan but to act.

If we are to plan and to act with a whole mind and heart, we must begin from an unreserved conviction that what we are doing is really worth while. To narrow the issue, are Archaeology and Anthropology worth while ? What indeed is the function of these sciences ?

The answer is not difficult. They are sciences of interpretation. What then do they interpret ? They interpret an endless succession of unique achievements of the human brain, unique reactions of the human consciousness to a multitude of combining or conflicting circumstances. Let me emphasise that word "unique". History never repeats itself. Its episodes are, each of them, the product of momentary conditions imposed by geographical and geological environment, climate, "race", tradition, "accident", a hundred and one factors which, added to the incalculable qualities of the human spirit itself, can never be expected to recur in identical form in the lifetime of mankind. They are each of them unique. The Altamira cave-paintings, the Parthenon, Chartres Cathedral, the Ajanta caves, the great

temple of Tanjore, the Taj Mahal, are each expressions of a *Zeitgeist* which is insusceptible to repetition, unique.

But there is more to it than that. I have just spoken of "episodes" of human history. That is a convenient but misleading word. The term "episode" suggests a degree of incidental detachment which does not in fact exist. The episodic treatment of history is a necessary artifice in the educational curriculum, but requires constant and specific correction. Without its context, the episode lacks perspective and significance. At the risk of labouring the obvious, I suggest a simple analogy. Suppose that all the words on a page of this book were loose, and that by shaking the page I could shake them into a heap on the floor. All the words, the "episodes", would be there, but their sequence and their meaning would be completely lost. Some system, some discipline, is required to re-arrange them in their significant sequence and so to restore their meaning. In the tumbled episodes of human history and prehistory that is the task of the humanistic sciences; of the historian, the archaeologist, the anthropologist. Their final function is the coordination of the works of man and the interpretation of these as an articulated and significant entity: their task, or a part of it, is to restore the fallen words to the page of the book, so that he who runs may read.

Thus it may, I suppose, be said that we, in our study of the works and days of man, have a twofold mission to fulfil. We must first set ourselves to analyse the individual works themselves with the patient objectiveness of the scientist; and secondly we must attempt to interrelate them, place them in their wider human context, and re-endow them, in short, with something of the three-dimensional vitality which created them. In the one role we are cold and calculating scientists, in the other we have or should have something of the imaginative comprehension of the artist. But let it be emphasised that the sequence of thought and effort is strictly in that order: first analysis, secondly reconstruction, the former always leading and controlling the latter.

Now this dual task is a complex and exacting one. That it is nevertheless "worth while" cannot be doubted by anyone who has sufficient respect for man to value the faculty which alone exalts him above the other animals. Let us remember again that the subject-matter of history, archaeology and anthropology is the expressed reaction of the human brain, in a succession of manifestations which cannot recur, to the physical and spiritual problems of existence. To exclude these reactions and manifestations from our thoughts is to deny a great part of our manhood and to become, however disguised, little more than human poodles scrounging perennially for the next meal.

The three sciences which I have named are not, therefore, mere academic luxuries. They are basic necessities in any society which has sufficiently emerged from the animal-stage to experience a sense of intelligent curiosity about itself. They are, above all, not merely the prerogative of a few specialists and cranks whose enthusiasms are private to themselves; they are, or should be, in some degree a part of the intellectual equipment of every educated man and woman. I would beg those of us who are professed archaeologists or anthropologists to bear this constantly in mind. Our duty is not restricted to a narrow circle of professors; we shall fall sadly short of that duty if we do not interpret also for the lay folk who are, equally with us, the co-heirs of the same inheritance.

On the present occasion, however, we are a congress of scientists, and for the most part indeed I have referred to archaeology and anthropology as

sciences. True, a few moments ago I suggested that we should in some degree aspire to be artists also. But to-day science is more fashionable than art. We are inclined to use the word science freely and sometimes rather loosely, and it is perhaps as well, before we consider the question of future planning, to determine a little more precisely the category of learning with which our special subjects are to be grouped.

It is fair to say that modern archaeology and anthropology are on the one hand increasingly employing the methods of natural science, and on the other hand increasingly employing the natural sciences themselves. Whether it is altogether true to say, quite bluntly, that they are themselves sciences in the normal sense of the term, I am less certain. They are, at the best, *inexact sciences*. For the mind can never wholly comprehend itself. The geologist can objectify his rock and (within the far-off boundaries of ultimate causes) can completely encompass it. The astronomer can even reduce the universe to objective mathematical and chemical formulae. But it is inevitable that to the mind, dealing with itself, a strong subjective element shall always be present. There is on earth no impartial arbiter of humanity. Humanistic science is fated to be an *inexact science*.

Accepting this regrettable conclusion, we need not as scientists despair of our estate. We have yet a very long way to go before, in our human studies, we attain the limits of objective truth and impend unsupported upon the abyss of subjectivity. Our discipline is primarily a science. Or, rather, it is a *synthesis of sciences*; and in our planning, at which I have now at least arrived, that is the controlling and informing factor. The problem to-day is primarily and urgently this: how are we in India to harness the natural sciences in the service of the study of man? How are we to create or coordinate the academic apparatus necessary for the analysis and objective understanding of his variegated achievement and environment through the ages?

Let us glance at the dimensions of our problem. In reconstructing the reactions of man to circumstance and experience, we have first to set the stage, to reconstitute the physical environment of his thoughts and deeds. The plan of his environment is the province of *geography*; the cross-section of his environment is the province of *geology*. The changing climate which apportions his working year and may involve vast movements of population make *climatology* an essential study. The plants which obstruct or aid his progress, feed or warn him, bring *botany* largely into the picture. The baffling but crucial problem of human "races", and of the sequence of faunas which have in varying degree conditioned human economy, introduce *biology* into our day's work. And now *chemistry* and *physics* have become our handmaids and will have an increasing share in certain of our studies. A formidable gathering of natural science has rallied round the science of man; and without it to-day the science of man has no meaning. Let me stress this with all possible emphasis: archaeology and anthropology can no longer be fobbed off with an odd lecture here and there in the arts curriculum. They have become *faculties* rather than departments of knowledge. This is a basic factor in our planning, and, before going further, I will pause for a moment to amplify a little the actual contributions which natural science makes today to humanistic science.

First, let us take geography. In India, the study of what may be called human geography has not begun. Years ago a civil servant from Madras drew attention to the subject in an excellent short paper in the *Indian Antiquary*,*

* F. J. Richards "Geographical Factors in Indian Archaeology", *Indian Antiquary*, LXII (1933), 235-243.

but his momentary lead has not been followed. And yet, of all regions of the world, India, with its combined continental and peninsular characters, its alluring coastal tracts, its great rivers, its vast plateau and vaster plains, and the mighty barrier of mountain which canalizes its landward approaches, cries aloud for the geographical study of its human history. It is now long since Sir Cyril Fox, Mr. O. G. S. Crawford and others began the detailed analysis of European geography from this standpoint. Fox's famous book on "The Personality of Britain" set the standard for this type of research as long ago as 1932, and that book was but the climax of much previous effort. What a fascinating task for an Indian scholar or group of scholars to produce an equivalent "Personality of India"!

And then geology. The mineral wealth of India is a familiar fact, and has been a constant stimulus to foreign trade which has, in turn, reacted upon Indian history. But in dealing with generalities I would not insist unduly upon that aspect of India's "human geology". Civilizations of a high order have subsisted with astonishingly little mineral wealth; the Indus valley civilization of the third millennium B. C. is an example. It is rather upon geology as a localizing factor that I would dwell—both in the form of hard rock of varying tractability, and in the form of surface-soil of varying fertility. In the rocks with which the builder has constructed his tombs and temples and palaces, and in the soils which have variously attracted or repelled the grazier and the farmer, lies the primary control of geology. The fissile granite of the south, split easily by fire into great slabs, encouraged the dolmen-builder to raise his megalithic graves and shrines and partly conditioned the massive medieval temple-architecture of the same region. The Deccan Trap of the centre provided a tempting medium for the cave-cutter of the Buddhist period. And, on the negative side, in the north the scarcity of rock in the great plains encouraged there the development of the brick-building which informed the evolution of the Northern school of architecture. Or again, the fertile alluvium and loess of the Punjab and its Sind extension induced that amazing development of prehistoric urban life to which I have referred; whilst the Jumna-Ganges Doab needs no archaeologist to proclaim its civic fame.

Integral with the geographical and geological factors is that of climate, which may either enhance or neutralize other advantages, and may stimulate or narcotize human effort. In Asia, with its enormous terrain, a few inches variation in the rain-fall will mean the life or death of millions of human beings, the migration of vast populations, the rise and decline of empires. The rhythm of invasion in and from central Asia has indeed been attributed unreservedly to rhythmic changes of climate, and, although the problem is a complex one still far from solution, there can be no doubt that the theory contains an important element of truth. It is manifest, for example, that the derelict cities in the desert of the Negeb of southern Palestine flourished less than fifteen centuries ago in a climate considerably more equable than that which ill-sustains a few wandering Bedouin at the present day. The same phenomenon is apparent in northern Afghanistan, where Balkh, the Mother of Cities, the ancient meeting-place of routes from China, the Mediterranean and India, now as a chaotic ruin dominates a scene of almost utter desolation*. Or, to come nearer home, the desert of Sind where the gaunt walls of Mohenjo-Daro have re-emerged from the sand must, in the 3rd millennium, have been nourished by cyclones that have long receded north-

* Mr. Evert Barger has recently re-directed attention to this site and to the climatic and other problems which its exploration should help to solve.—*The Geographical Journal*, CIII (London, 1944), 1 ff.

wards, thereby not only depopulating the flanks of the Indus valley (save where modern irrigation has intervened) but at the same time placing a natural and significant bulwark between Southern Iran and Rajputana. It was, for instance, this bulwark of desert, more than any other factor, that barred the eastward penetration of Islam after the Arab conquest of Sind in A. D. 712.

The part played by botany in the reconstruction of human environment is obvious, dealing as it does with food-plants and their cultivation, the character and distribution of forest and jungle, and the influence upon plant life of geographical, geological and climatic factors. But there are three points which I would emphasise in connection with botanical research. First, there is the great importance to our studies of further work in connection with the ecology or distribution of food-plants. Whatever be our definition of the term civilization, there can be no doubt that stability of food-supply is a necessary premise, and that agriculture therefore is an essential factor. Thus, in tracing the early diffusion of civilizations, we have constantly to consider the distribution of cereals, notably wheat and rice, without one or other of which human progress beyond a certain point would scarcely have been possible. Here in recent years the Russians have contributed interesting data which, when amplified and verified, will have far-reaching implications in our reconstruction of Asiatic prehistory. Working from the axiom that the original home of a plant is likely to be that region where its most numerous species are found, the Russian Vavilov has discovered in Afghanistan an early home of the bread-wheat. This is, for us in India, a notable fact, if true. It is remarkable indeed how often our paths of research lead us into the mists of that unknown country. We may trust that the time is now not distant when our Afghan neighbours may open their gates freely to the scholars of the world. There are hopeful signs.

The second point is the importance of the recovery from ancient soils of the evidences of the plant-life which was contemporary with them and with the human evidence which they may contain. It is now about twenty years since this matter first received systematic attention in connection with humanistic studies; and now, under the lead in Britain of the University of Cambridge, the analysis of soils for the recovery and identification of plant-seeds has become a matter of routine as a sequel to archaeological excavation in the West. In favourable conditions, by pollen-analysis it is now possible to recover the essential elements of the vegetation, and therefore of the climate, of remote and alien phases of the world's history or prehistory. The process is as indispensable for our studies in India as it is in Europe. But at the present time there is no laboratory in India to which we poor archaeologists can, as a matter of routine, send soil-samples for pollen-analysis. In other words, a whole avenue of research is closed to us.

My third point under the heading of botany really comes under the sub-head "dendrology", and relates to the study of the growth of trees. Here the lead has been taken by an American, A. M. Douglass, who has successfully applied the data of tree-growth to the prehistory of man. The principle is a simple one, although its accurate application involves a number of complexities. As every schoolboy knows, a section across a tree-trunk reveals a number of concentric rings of varying width, each ring representing a year's seasonal growth, which will be extensive in a wet year and restricted in a dry one. Working in western America upon trees up to 3000 years old, and cut down at a known date, Douglass has shown the possibility of producing backwards a tree-ring timetable and climate.

chart, in which can be recognized a rhythm or periodicity as shown by the varying size of the growth-rings. These periodical fluctuations approximate closely to the cycle of sun-spots, and reflect directly the fluctuations of climate which are influenced by that factor. In trees that have grown up in a climate with marked seasonal changes, which produce clear and accurately measurable rings, a considerable degree of precision in this tree-chronology can be achieved; to such an extent that, in a given region, it is possible to correlate the inner rings of young trees with the outer rings of old trees, and to place trees used in ancient structures into their proper place in the time-scale. Thus, though the written history of America does not begin until the end of the 15th century, it has been possible for Douglass, by tree-ring analysis, to date a prehistoric pueblo in Arizona to A.D.1074.

How far this remarkable method may be applicable to India I do not know: it has not been tried out. There is some evidence that it will be workable in West Africa, and before the war its possibilities were being explored in Europe—though there the seasonal changes are probably not sufficiently clear-cut to produce accurate results. In India, it is at least worth a serious trial.

Here then are three ways, in which the botanist can help the archaeologist. I have not exhausted the possibilities, but have probably said enough to show that the botanist is an essential member of our team.

Biology, whether human or animal, touches our studies at many points which are familiar to us all. No systematic or sustained attempt has yet been made to trace the specific variations of the Indian fauna in relation to human chronology, and much work will, it is to be hoped, be done in this matter when the fieldworker is able to produce adequately classified material. Meanwhile there is a perennial biological problem on our doorstep, whether we be archaeologist or anthropologist: the problem of the definition of the term Race. The need for an objective definition of this ill-used word is as insistent as are the difficulties in the way of solution. A quarter of a century ago the problem seemed to have been settled. The criteria of race were primarily skull-measurement, stature and colouration. The measurements of bones were standardised with great precision, and, though the recording of the colour of skin, eyes and hair remained somewhat subjective, a general all-round agreement was reached on this composite basis. I need not take you further over the well-trodden ground. But more recently these criteria have been widely questioned. There has been an increasing tendency to affirm the control of environment, not merely upon colouration, but even upon skeletal form. And alongside this growing scepticism, the value of blood-groups as race-indices has been acclaimed with a somewhat rash optimism. Here, in the composition of the blood, we have a phenomenon susceptible to objective classification, a genic character determined by heredity and not, so far as is known, affected by environment. Four main blood-groups have been isolated and labelled internationally A, B, AB and O, with a number of sub-groups. The scope of this classification is not yet sufficiently clear for final judgment by the anthropologist; the task of collecting accurately grouped data is a huge one, and vast regions of Asia which are important in this context are difficult of access. But it is already apparent that blood-groups alone cannot supply the need vaguely indicated by the word Race. For instance, as Dr. D. N. Majumdar pertinently observes, "the predominance of B in India and Mongolia inhabited by different racial stocks requires explanation"*. Furthermore, the speed and conditions of mutation are unknown and perhaps variable factors. And

* *Races and Cultures of India* (Allahabad, N.D.), p. 54

the knowledge that the higher apes possess the same blood-groups as man raises a doubt whether these mutations are sufficiently modern and sufficiently sensitive to assist the explanation of any significant human groupings within our reach. We do not at present know. It is possible that a combination of skeletal and genic data may eventually give us the nearest approximation to a scientific definition of Race. The problem is full of interest; more so perhaps in India than in most other parts of the world, for the variety and rigidly cellular structure of Indian society, with its traditional endogamy, offers a special scope for trying out the validity of blood-group analysis in a relatively restricted field. Exactness in the classification of data, and plenty of them, are the first requisites of this study.

Lastly in my list of sciences I come to our old friends, chemistry and physics. Old friends but in a new guise. The scientific analysis of soils and gravels has, in recent years, been carried forward to a stage where it has become no longer a luxury but a necessity to the archaeologist. Many scientists have contributed to this study, but the protagonist has been Dr. F. E. Zeuner, a refugee from Germany under the Nazi regime and now a citizen of Great Britain. There, at the British Museum (Natural History) and the University of London Institute of Archaeology, he has developed analytical technique and collected and collated data bearing upon the environment and chronology of man from the earliest times down to comparatively recent periods. By mechanical analysis he separates sands, loams, brick-earths and other soils into individual grains and so determines their different grades or weights. The method is based upon the suspension of a certain quantity of the material in water, the coarser and heavier grains settling down more rapidly than the finer ones. In many cases it is possible to find out in this way whether the grains were deposited originally by wind or by water—a vital factor in the reconstruction of climate. For instance, comparative analyses of wind-blown dust deposited on snow, on the one hand, and of apparently identical dust from river-silt, on the other, have shown that 80—97 per cent. of the wind-blown grains are as small as 0·07—0·01 mm. or even less, whereas only about 66 per cent. of the water-deposited grains are of that minuteness. On this basis it is not difficult to determine by analysis the general conditions of climate, etc., under which ancient soils were laid down, i.e. the conditions of climate under which man contemporary with these soils lived.

Furthermore, by analogous methods (including chemical analysis) which I need not attempt to describe to you now, it is possible to determine whether a deposit has been subjected to secondary weatherings. In other words, it is possible to reconstruct objectively a *climatic sequence*, important not merely in itself but as facilitating a comparison between analyses from different regions and so producing a chronological relation between those regions; the essence of the comparison being that an extensive and complex sequence of climatic changes occurring at similar intervals in two regions may be taken to imply approximate contemporaneity for the two series of deposits.

Similar to mechanical analysis is gravel-analysis. It is common knowledge that the earlier phases in the story of man are interleaved or punctuated by the emphatic incidence of climate of arctic or pluvial type, which may itself be diversified in a multiplicity of ways. The most informative index of these climatic variations and sub-variations is provided by successive riverbeds or terraces, and the analysis of samples of gravels from the different terraces of the same river is capable of producing a remarkable body of information. The gravel is passed through a set of sieves of graded mesh and

is thus itself graded according to size. Each grade of the gravel is then sorted into the different varieties of rocks and minerals composing it, and the result is usually represented in percentage figures. These figures may yield the following information* :—

- 1) Any alteration of the catchment area, and the relative period of each alteration.
- 2) The date of volcanic events in relation to the sequence of terraces.
- 3) The relative age of glaciations which invaded, or touched, the river area ; detected by the introduction of the pebbles of foreign rocks.
- 4) In certain river areas, where the gravel is of a varied character, the composition of the gravel can be reproduced in the form of a curve showing the respective frequencies of the components in the various grades. The form of the curve is influenced by-climate during the deposition of the gravel : in a dry climate hard but chemically little resistant rocks (like felspar) survive even into the small grades, whereas in a wet climate chemical action is brought to bear and rapid destruction ensues.

When studying systems of river-terraces in this way, we may expect to arrive at a detailed sequence of climatic events, with (in favourable circumstances) fossil human industries closely correlated with them. And this evidence has in a number of cases been equated with the parallel evidence of soil-analysis; so that, in the aggregate, a firm sequence of climatic phases and human cultures has been worked out in those regions which have been adequately studied.

But the marvels of Geochronology, as this new application of chemical and physical analysis to humanistic science has been called, do not end there. I have spoken so far only of the *relative* chronology which the study of these sequences has produced. Already, however, this technique is reaching beyond the relative to the absolute. "The climatic fluctuations which have been established, based on the work of a great number of authors on loess-sections and river-terraces, have surprisingly been found to agree closely with certain fluctuations of the intensity of solar radiation, calculated on an astronomical basis. This enables one to arrive at probable approximate dates for the palaeolithic cultures". By dates in this context are meant *absolute* dates, a fixed chronology. Thus it has been deduced that the oldest palaeolithic culture of Europe flourished approximately from 550,000 to 470,000 years ago, and an absolute time-table for the later cultures, in relation to glacials and inter-glacials, has also been worked out.

Now how does India come into all this? At present not at all. But the raw material is here in abundance. We have great rivers, rivalling those of Europe. We have ancient industries, often resembling closely those which, in Europe, Dr. Zeuner and others are beginning to put into a time-scale. If we have not the same wealth of glacial material which sub-Arctic Europe accumulated, we have evidences of pluviation which await analytical correlation with the pluvials of Africa and, indeed, with the glaciations or inter-glacials of Europe itself. Meanwhile, in the absence of geochronological research here, we have no right to apply to India, even provisionally, the results of European investigation. We must stand upon our own feet—or, rather, we must get going upon our own feet—prepared for the possibility that India may extract from these methods a different answer altogether. Be that as it may, the roots of mankind in this sub-

* I am abbreviating from F. E. Zeuner, *First Annual Report of the University of London Institute of Archaeology* (London, 1937), 42,

continent, extending downwards probably for hundreds of thousands of years, can never be studied adequately until somewhere in India we set up a geo-chronological laboratory and train some of our best young scientific brains to work it.

Well, there we have an imposing array of sciences, all of which contribute to our special studies, and, furthermore, none of which can nowadays be neglected in them. I have said nothing of what may be called the more domestic technique of archaeology itself, and I am not sufficiently experienced as an anthropologist to venture into the special problems and methods of that sister-science. In archaeology, much could be said nowadays of the increasing subtlety of the technique of excavation; and much, above all, of the essential value of air-observation and air-photography in archaeological fieldwork, particularly in a country such as India with its vast spaces, often difficult of approach on the ground. Who knows what a systematic air-survey of the Thar or Indian Desert might reveal? or of the great plains themselves with their teaming vestiges of age-long habitation? The time has come for something more than attractive obliques of the Taj Mahal. The taking and interpretation of air-photographs is to-day in itself an evolved technique. In the north-west, the new Royal Indian Air Force has already taken a number of excellent photographs for my Department. Once more, the ability is there, but it needs stimulus and coordination. It is now thirty years since the Germans led the way in this "archaeology from the air", and over twenty years since air-photography was first generally recognized as a necessary concomitant of archaeological research in Great Britain. In Palestine and Iraq the most dramatic results have been yielded by this method of detection and correlation. Let us get air-archaeology going in India, not in the opportunist fashion in which it is on very rare occasions operated at the present time, but on an organized, carefully thought-out plan. On such a basis we may reasonably expect, I think, cooperation from the Survey of India, from the R.I.A.F., and also before long, it is to be hoped, from Indian civil aviation.

There then, in the barest outline, are the main factors for consideration in planning the future of the study of the material heritage of India. The problem is a formidable one but not impossible of solution. It is evident, as I remarked earlier, that the primary need is not for scattered lectureships of a more or less amateur kind sprinkled broadcast over the academic landscape, though these might ultimately have a certain utility in a secondary sense. *The real need is for a centralized school of archaeology of a highly specialized kind.* Without that we cannot hope to raise humanistic science in India to the international level which is its rightful place. But let us not despair before the prospect of so much concentrated specialization, or the immense budget which that might seem to imply. At the present time one of the more popular slogans is "coordination". All over the world we find coordinating committees, with super-committees to coordinate them in turn. And now, in our particular need, *coordination* supplies a great part of the answer. Most (not all) of the sciences to which I have referred are already being taught and studied in many of the Indian universities. What is needed is that in some one of our universities these departments of science shall be in a measure adapted specifically to the requirements of humanistic research: that geologists, for example, may be persuaded to give more attention than at present to Tertiary and Quaternary geology, even though it be of less immediate economic value and, incidentally, more elusive and difficult in itself; that botanists may develop the technique of pollen-analysis and the further investigation of plant-ecology in relation to human problems;

that somewhere in a physical laboratory a section may be set aside for the analysis of soils and gravels. All this can be achieved by a relatively slight expansion of present equipment and enterprise. But behind it all must be the trained archaeologist, busy in the blessed act of "coordination"; stimulating, inspiring, driving, even wheedling, his fellow-scientists into a combined concern in this great central study of mankind, Man. The modern archaeologist—and I have no doubt that the same thing applies to the modern anthropologist—must be as much a diplomat as a scientist. He must be a scholar, he must be an organizer amongst busy men, he must be a leader and, not least, his directed enthusiasm must be such as to ensure the cooperation of his colleagues and the creation of a following of worthy shape and size. He must be employed by a university equipped with scientific departments and sympathetic to humanistic studies. He must obviously for a while be sent abroad for such technical training as his country may not yet be in a position to provide. In due time he will require the assistance of a small departmental staff. These various desiderata are easy to set down on paper; but they are also not difficult or disproportionately costly to realize in fact. Amongst the youth of India there is, as I well know, the zest to learn and the ability to achieve. It is for us of an older generation to provide the essential apparatus and the necessary opportunity. Let us not fail. Now, I submit, is the time to act.

SECTION OF MEDICAL AND VETERINARY SCIENCES

PRESIDENT : RAI BAHADUR K. N. BAGCHI, M.B., D.T.M., B.Sc., F.R.I.C., F.N.I.

THE INSIDIOUS TYPE OF LEAD POISONING

A DANGER IN POST WAR INDUSTRIAL RECONSTRUCTION
AND A PLEA FOR DEVELOPING INDUSTRIAL HYGIENE
AND MEDICINE

(Delivered on 4 January, 1946)

I must express my sincere thanks for the honour of having been invited to preside over the Medical and Veterinary Sciences Section of the Indian Science Congress this year. Before proceeding with my address, I must frankly state that being a laboratory worker all through my life and being fully conscious of my limitations, I hesitated for a considerable time to fix upon a subject suitable for this occasion. As it has been the general convention with the Sectional Presidents to deal with subjects on which they have worked, I have, therefore, selected the subject of lead poisoning which possesses a peculiar fascination for me and which kept me fully occupied for about 10 years. The subject, I am sure, would occupy a far more important place in medicine, both curative and preventive, as soon as the various post-war industrial schemes are implemented. In this address I shall present before you some of the important features of my investigations on lead poisoning and its bearing on post-war industrial reconstruction.

Lead is found everywhere in this lead bearing planet. It is the normal constituent of the soil, water, vegetation and the particles of dust floating in the air. Animals and human beings too have lead to an appreciable extent in their tissues.

By the term lead poisoning or plumbism, we understand that one has imbibed lead in quantities larger than what are normally ingested with the food and drink or inhaled with the air or otherwise absorbed, and has been adversely affected or intoxicated by it. Lead poisoning like all other kinds of poisoning, fatal or otherwise, may be acute or chronic. The acute form of lead poisoning is met with in connection with cases of criminal abortions by taking lead compounds, or cases of syphilis and other diseases treated by village quacks with large doses of red lead, litharge (*mudrasang*), etc., or cases caused by inhalation of massive doses of lead fumes in smelting and other metallurgical processes. These cases do not show the characteristic signs and symptoms as described in text books and usually end fatally in a few days. The acute cases have, therefore, been excluded from the scope of this discourse. I would discuss only the chronic form of lead poisoning which has been known from very ancient times—from the time of Hippocrates (about 400 B.C). It is mostly of occupational or industrial origin and to a less extent accidental. The cases of occupational lead poisoning are met with in this country among the solderers and tin-mistries who mend and tin (*kalai*) cooking and other utensils, the compositors in printing

presses, the plumbers, the paint *mistries* who use grease-paints containing lead compounds for painting doors, windows, etc., and persons engaged in similar other occupations. The industries in which lead and its compounds are used are numerous. It is stated by the U.S. Department of Labour that there are about 150 industries and occupations which offer exposure to lead. It is needless to say that most of these industries are at present unknown in this country but with the gradual industrialization for which intensive schemes are now being formulated for post-war reconstruction, quite a large number of these lead industries are bound to develop in India.

Accidental poisoning comprises cases in which poisoning follows the drinking of water contaminated with lead, the cooking or storing of foods in vessels coated (*kalai*) with lead or with tin adulterated with lead, or the use of vermilion (*sindur*) containing red-lead as occurs among Hindu women particularly in Bengal, where numerous brands of this article containing red lead and a scarlet synthetic dye, have been put in the market and which have become more popular since the stoppage of the import of pure vermilion (*cheena sindur*) from China during the war. It may be mentioned here that cases of lead poisoning caused by the use of face powder containing lead compounds used to occur in large number among Chinese women in the Federated Malaya States but legislative measures prohibiting the manufacture, sale and advertisement of lead containing powders produced a very satisfactory result in a few months.

TOXICITY OF LEAD AND LEAD COMPOUNDS

Lead in whatever form it is introduced in the system, acts as a poison. Even metallic lead is a potent poison—the toxicity depending on the extent of its surface exposed to tissues. A lead bullet, for instance, embedded in a tissue is much less poisonous than the same weight of lead if introduced in the system in the form of dust, because the total surface of the dust particles is several hundred times greater than that of the bullet. The solubility of lead and its compounds in the blood serum (not in water) also determines their toxicity. Some insoluble lead compounds such as 'white lead' 2PbCO_3 , Pb(OH)_2 , litharge PbO , red lead Pb_3O_4 , etc., are more dangerous than many soluble lead compounds because they are relatively more soluble in blood serum than in water. The following table shows the relative solubility of these compounds in water and blood serum (Jacobs, 1941).

TABLE I

Figures indicate solubility of lead compounds in milligrams per litre at 25°C.

Lead compounds	In blood serum	In water
Lead (metallic)	578.0	—
Lead monoxide (litharge)	1152.0	17.1
Lead Carbonate (PbCO_3)	33.3	1.7
Lead Sulphate	43.7	44.0

The route by which lead is introduced into the system is also a determining factor in the causation of the toxic symptoms. Lead is absorbed through the skin, the alimentary tract and the lungs. It has been proved that lead is absorbed in larger quantity and much more quickly through the

lungs than through the alimentary tract or the skin and that lead introduced into the system by inhalation is about 100 times more toxic than when it is swallowed (Johnstone, 1942). In the latter condition most of the ingested lead is eliminated through the intestinal tract without being absorbed in the system. The absorption through the unbroken skin is, however, a slow process but poisoning occurs frequently following the continued use of hair dyes, hair-lotions, cosmetics and paints, which fact has been proved experimentally on laboratory animals by American workers (Kehoe and Thaman, 1931). The application of vermilion containing red lead to the hair parting or forehead by Hindu women, as stated before, has also been a source of lead poisoning among them (Bagchi, 1941). It is believed that women are more susceptible to the action of lead although this view is not shared by the German writers who consider that "their poor state of nutrition, poverty and industrial fatigue added to house work, long hairs and type of clothing favouring the accumulation of a greater quantity of the poison upon them account for an apparent increased susceptibility". But all agree that in women lead poisoning assumes a more severe form (Biondi, 1934). The above remark, particularly the reference to the poor state of health and poverty, applies perhaps with greater force to Indian women, and they are, therefore, more liable to lead intoxication, whatever be the source of lead or the route by which it is introduced into the system.

THE INSIDIOUS TYPE OF LEAD POISONING—ITS PATHOLOGY AND SYMPTOMATOLOGY

The classical type of lead poisoning or plumbism in which all the characteristic signs and symptoms described in text books, such as wrist-drop, optic atrophy, anaemia, colic, obstinate constipation, etc. develop, offers, no difficulty for its diagnosis. Such cases are only met with among people who imbibe massive doses of lead under conditions brought about by their occupation. But quite a large number of people who happen to absorb only very small amounts of lead over a long time either from drinking water, cooking utensils, vermilion, or similar other sources do not develop any of these symptoms and yet are known to suffer from plumbism. In these cases lead does not cause sufficient damage to the organs necessary for the production of the text book symptoms. It has been stated (Porritt, 1931) that 'a slow, subtle, insidious saturation of the system by infinitesimal doses of lead extending over a long period of time produces a group of symptoms altogether different from the recognised forms of plumbism'. In this type of poisoning, cases with vague and indefinite symptoms of dyspepsia, slight anaemia, etc. are brought to the notice of the physician, but they are invariably mistaken for something else. These cases have lately attracted the attention of the workers in this line and have been proved by chemical and therapeutic tests to belong to the insidious type of lead poisoning which had hitherto escaped the notice of the clinicians.

The signs and symptoms of the insidious type are in most cases those of dyspepsia, such as loss of appetite, distaste for food, slight constipation, occasional looseness of bowels with mucus (enteritis saturnina), flatulence, abdominal discomfort bearing no definite relation to food, and slight anaemia. In many cases slight arthralgic pains round various joints—the knees, elbows and shoulders being most frequently affected—are the only symptoms available (Price, 1929). In certain cases arthritic pain with creaking or grating and slight impairment of movement and sometimes with slight swelling of a joint, may be present. Symptoms simulating gastric ulcer or malignant gastric disease with diarrhoea, vomiting and abdominal pain, but

without hæmatemesis or melæna have been recorded (Bramwell, 1931). Vertigo, headache and insomnia may also be the only symptoms noticeable. (Price, *loc. cit.*) Lethargy, weariness of the brain, sleepiness, disinclination for any effort with emotional outbursts particularly in women, mental confusion, and "bright girls becoming gloomy, taciturn and miserable" with no other indications for lead poisoning, have been known to be the characteristic features in the insidious type of poisoning (Porritt *loc. cit.*) Neurological manifestations, such as weakness of the extensors of the right hand, lower arm, the interosseus muscles and also of the shoulder muscles (Leschke, 1934), spastic paraplegia, anterior crural neuritis with snomalous symptoms and a mild form of lead encephalopathy with symptoms of brain tumour (Bramwell, *loc. cit.*) have also been recorded. Candy (1933) reported a case from Bombay in which mental confusion, paraplegia and paræsthesia were the marked features—the man fell down unconscious on the road and remained so for 3 days but made a rapid recovery under treatment for lead poisoning.

In women, menorrhagia and metrorrhagia have been known to be the principal signs in some cases and in fact these signs along with signs and symptoms of dyspepsia appear to be the most common indications of this type of lead poisoning. A married girl developed mental confusion (duration 1 year) with slight spastic paraplegia and nystagmus (8 months) severe menorrhagia and metrorrhagia (4 months) and a history of abortion (2 years ago) and it was found that she had been imbibing lead for a considerable time from tinned utensils (Candy, *loc. cit.*) Damage to germ cells in both sexes is the characteristic feature of lead absorption. Sterility and abortions are, therefore, frequently met with among people who are exposed to lead. The lead workers who show no signs of lead intoxication and are apparently of good health have been known to be sterile or subject to repeated miscarriages. Leschke describes the case of a woman who had previously given birth to three normal children and who had after her subsequent employment as a lead worker nine miscarriages. The same author cites another case in which a woman who was not herself exposed to lead in any form but whose husband was a lead worker, had only miscarriages and still births, but in a new marriage to a healthy man who was not employed in any lead work, she had healthy offsprings.

Lead causes damage to the fetus itself and also to the chorionic epithelium which is believed to have a special affinity for lead. If a mother suffering from lead poisoning suckles her baby, she transmits lead through her milk and sets up a slow and progressive poisoning in the child (Biondi, *loc. cit.*) Lead affects children equally badly and in insidious cases only the gastro-intestinal symptoms may be present (Taylor and Schram, 1936). The relative immunity of children advanced by some authors is without any foundation. The children born of mothers suffering from plumbism have been found less healthy and frequently undersized and weakly, and are prone to be degenerate showing macrocephaly, idiocy, imbecility and epilepsy (Biondi). Congenital debility in infants, marasmus, wasting, convulsions, obstinate constipation or enteritis with or without jaundice, are frequently traced to lead intoxication and may be the cause of death of a large number of children (Milligan, 1931). The children in Hindu households, particularly the girls living, as they do, in close association with their mothers and sisters who are exposed to lead (using vermilion adulterated with red lead) have been found to imbibe appreciable amounts of lead mostly through the respiratory route (Bagchi et al, 1940, vide Appendix C). If the amount of lead absorbed by these children exceeds the normal limit,

and it is bound to exceed since the exposure continues indefinitely, they are liable to develop, sooner or later, the insidious type of poisoning.

Lead increases the incidence of eclampsia—the amount of lead imbibed daily may be insignificant but 'it may be enough to turn the scale and precipitate the occurrence of eclampsia in a pregnant woman on the verge of toxæmia'. High maternal mortality is significant among women exposed to lead (Porritt, *loc. cit.*).

Vascular spasm is an important effect of lead absorption and its manifestations may be noticed in various forms in different organs of the body. The vessels lose their dilatability and no longer dilate even with caffeine, nitrites, etc., but, paradoxically, are decreased in size by these drugs (Leschke, *loc. cit.*). No blood vessels escape the effects of lead; the splanchnic, renal, retinal as well as the blood vessels of the brain may be equally affected. These spasms are at first functional but may gradually bring about permanent pathological changes. Chronicity of spasms in the blood vessels of the hair follicles of the scalp may cut off nourishment and thus give rise to 'falling out' of hair, a mild form of alopecia which is a common complaint among Hindu women using lead-containing vermilion, and may be regarded as a manifestation of the insidious type of poisoning.

DIAGNOSIS OF LEAD POISONING

"It is a sad commentary upon medical education," says an American author, "that a disease known to the ancient Greeks, Latins, Arabians, and studied by physicians throughout the subsequent centuries inciting profuse materials in medical literature, and having such well-defined laboratory findings, should remain an enigma to the profession at large. Few, if any, of the occupational diseases are so constantly erroneously diagnosed as lead poisoning" (Johnstone, 1942).

History of exposure: In the diagnosis of plumbism, the history of exposure to lead is a very important factor. This guides the physician in the right direction and the laboratory findings confirm his suspicion while the clinical picture helps him to clinch to his diagnosis. These three form the triad of diagnosis. If we lay stress on one or two of them and overlook the third, the result will be fallacious. For instance, in a lead worker getting slight pallor of the skin, a general feeling of malaise, loss of appetite, slight constipation, etc., which are frequently met with in early cases of plumbism, but may also be due to several other causes, the diagnosis of lead poisoning without determining the lead contents of the urine and faeces is likely to be erroneous, for the analytical report may not, after all, show any abnormal lead absorption. Similarly, in another case having a definite history of exposure and laboratory findings indicating high lead absorption, but having no complaints of any illness, the diagnosis of lead poisoning on the basis of the laboratory findings alone is certainly erroneous, because lead absorption does not necessarily mean lead intoxication. Such errors in diagnosis are rather too frequent in industrially developed countries and in fact as much as 60% errors are not uncommon. The consideration of monetary gain under the Workmen's Compensation Act is partially responsible for this state of things. It may also be noted here that in factories where preventive measures have not been installed, the workers imbibe considerable quantities of lead but quite a large proportion of them appear to develop a form of immunity, and only a small proportion having an idiosyncrasy for lead develop symptoms of poisoning in a few months. The analytical findings in both groups of cases may, however, indicate absorption of lead to the same extent.

Laboratory Tests : Fæces and Urine—The examination of fæces, urine, etc., by modern methods of chemical analysis has revealed that lead is normally present in all biological materials and their normal limits which vary widely in different countries have been worked out. The following table shows how widely the normal lead content of the urine varies in different nationalities :—

TABLE II

Comparative statement showing lead contents of normal urine in different nationalities—figures indicating milligram of lead (as Pb) per litre or part per million.

Nationality	Minimum	Maximum	Average	Investigators
German	0.01	0.55	—	Litzner and Weyrauch, 1933
American	0.04	0.08	0.05	Kehoe <i>et al.</i> , 1935
British	Nil	0.133	0.04	Francis, Harvey and Buchan, 1929
Australian	0.02	0.05	0.04	Cooksey and Walton, 1929
Indian including Anglo-Indian	Nil	0.04	0.018	Bagchi, Ganguly and Sardar, 1939

This wide difference is due obviously to the degree of industrialisation attained by the countries concerned. In the highly industrial cities of the West, the atmosphere is surcharged with fine dust containing lead and other metals which gain easy access into the system through the respiratory route. The following table compares the toxic condition of the atmosphere of the city of Calcutta with that of Leeds in England and thereby gives an idea of the backwardness of Calcutta regarding its industrialisation. For this analysis samples of fine dust were collected from the tops of cupboards and other furniture and from the electric casings on the wall in different parts of the city. The floor dust which is always gritty and not being representative of the atmospheric dust, was avoided for the purpose of this investigation.

TABLE III

Lead contents of dusts of Calcutta and Leeds. The figures indicate milligrams per kilo of dust.

	Calcutta (Bagchi & Bhattacharjee, 1943)				Leeds (Manley, 1937)	
	Medical College	Amherst Street	Bally-gunge	Sham-bazar	Industrial portion	Residential portion
Copper (as Cu)	Nil	Nil	Nil	Nil	416.0	Nil
Lead (as Pb)	5.0	17.0	17.6	41.0	3025.0	1725.0
Arsenic (as As ₂ O ₃)	20.0	6.6	6.6	14.0	476.0	384.0

After its absorption in the system, lead is partly retained in the tissues and partly eliminated with the urine and fæces. The urinary lead

excretion does not increase proportionately with increased lead exposures beyond a certain limit and this limit, the 'threshold value' as termed by Kehoe and co-workers (1933), appears to vary widely in different individuals. The faecal lead excretion is, on the other hand, an important guide for determining the lead absorption. It has been experimentally proved by several workers that a considerable portion of the lead in the system is eliminated through the faeces and only a small fraction is left for the kidneys to eliminate through the urine. The faeces contain (1) unabsorbed

TABLE IV

Lead in normal urine and faeces. Figures indicate mgm. of lead per litre or kilo (Bagchi & Ganguly, 1937).

	Urine		Faeces	
	Minimum	Maximum	Minimum	Maximum
Hindus	Nil	0.016	0.08	0.14
Muslims	Nil	0.026	0.10	0.16
Anglo-Indians	0.024	0.040	0.13	0.18

TABLE V

Comparative statement showing the lead contents of the urine and faeces of (i) healthy persons not exposed to lead, and (ii) of persons exposed to lead, e.g., women using lead containing vermilion and men engaged in occupation involving the use of lead. Figures indicate mgm. per kilo or litre.

	Urine	Faeces	Remarks
Group I: Healthy Indians not exposed to lead in any way (from Table IV)	Nil to 0.026	0.08 to 0.16	
Group II: Women of respectable families using lead-containing vermilion			
Case No. 1.	0.059	1.29	Suckling mother, quite healthy.
Case No. 2.	—	1.05	Six year old girl with dyspeptic troubles and slight anaemia. Not actually using vermilion but may be regarded as a 'contact'.
Case No. 3.	0.02	1.04	Abortions with negative W.R.
Case No. 4.	0.008	1.52	Dyspeptic troubles with mild alopecia.
Case No. 5.	0.08	0.88	Mild alopecia. Otherwise healthy.
Group III: Compositors and solderers			
Case No. 1.	0.06	2.4	Suffering from lead poisoning—some showing the usual text book symptoms.
Case No. 2.	0.124	1.05	
Case No. 3.	0.144	4.46	
Case No. 4.	0.164	2.28	
Case No. 5.	0.530	4.50	

lead normally present in food (vide Appendix B), (2) unabsorbed extraneous

lead ingested with food, (3) lead absorbed from the alimentary tract and excreted again into this tract for elimination, and (4) lead introduced into the general circulation through routes other than the gastro-intestinal and mostly excreted by way of the liver and bile. It is, therefore, evident that the amount of faecal lead must be many times more than the amount of lead in the urine. The faecal lead accordingly indicates the actual degree of lead exposure and absorption. The preceding tables (Tables IV and V) confirm the point discussed here.

Blood : The chemical examination of blood does not help in any way in cases of insidious type of poisoning—the lead figures lying always within the normal range which is between 0.11 and 0.45 mm. per kilo (vide Appendix A). In chronic cases, even with well developed symptoms of lead poisoning the blood lead does not usually exceed the normal limit, but in cases undergoing deleading treatment or having acute exacerbation, the lead figures pass beyond this limit. The whole amount of the lead in normal blood is contained in the cells and fibrin fraction and practically nothing in the plasma. In the blood with abnormal lead content, the plasma contains only about 10% of the total amount of lead. The lead content of blood considered normal in the U.S.A. for the purpose of administration of the Workmen's Compensation Act has been fixed at 0.1 to 0.5 mg. per kilo.

Tissues : The low lead content of air, water, soil, foodstuffs, etc. of this country (vide Appendix B) in comparison with highly industrialised countries and the consequent introduction of less amount of lead into the system are responsible for comparatively low lead figures of the urine and faeces

TABLE VI

Comparative statement showing the lead contents of normal human tissues of different nationalities. Figures indicate mgm. per kilo.

	Indian. Bagchi et al 1939	American Kehoe et al 1933	British Tompsett & Anderson 1935
Liver	0.82	0.80	4.63
Kidney	0.71	0.70	2.60
Heart	0.75	Trace	—
Lungs	0.60	0.30	0.88
Intestines	0.68	0.20	—
Spleen	0.52	Trace	5.9
Cartilage	3.25	2.60	—
Skin	0.50 (skin) 1.20 (scalp)	— 1.30	— —
Brain	0.10	0.10	0.72
Bones	39.3 (humerus) 8.5 (rib) 14.86 (flat)	— 11.4 (long bones) 11.1 (flat)	— 12.9 (rib) —

and also of the body tissues of Indians (vide Tables II and VI). Lead, it is believed, is transported into the general circulation in the form of soluble lead phosphate or as finely divided colloidal lead phosphate for deposition in the trabeculae of the bones in the form of insoluble tertiary lead phosphate.

Bones are therefore called the 'lead depots' of the human system. Deleading agents such as potassium iodide, sodium bicarbonate, phosphoric acid, calcium salts, etc., convert the insoluble form to soluble lead phosphate and cause its reappearance in the blood in larger quantities for elimination through the usual eliminatory channels.

The American figures given by Kehoe as shown in table VI were obtained from the tissues of a Mexican Negro (stabbed to death) living a primitive life in a village far from industrial cities (comparable to an Indian villager). The figures are, of course, much higher in people who live in big cities. The Indian figures were obtained from post mortem materials of cases of rapidly fatal street accidents, of shooting, stabbing, suicidal hanging, etc., comprising Bengalees, Biharis, Punjabis and other provincials (taken from Appendix A). No hospital case or cases with a terminal illness causing partial starvation and thereby a disturbed metabolism and an interference with the normal intake of lead, were included in this investigation. The British figures were, on the other hand, obtained by Tompsett and Anderson from hospital cases of large industrial cities where exposure to lead is inevitable; these figures are, therefore, comparable with those obtained from Indian cases with definite history of lead exposure as shown in the table below.

TABLE VII

Lead contents of tissues of persons with abnormal lead exposure. Figures indicate milligrams per kilo (Bagchi et al, 1939).

Tissues	Hindu male aged 40. Death due to fracture of skull	Hindu male aged 26. Death due to shock from injury	Hindu female aged 22. Death due to burn
Liver	3.60	1.5	0.98
Kidney	3.90	—	4.0
Heart	0.90	—	0.24
Lungs	1.00	3.6	0.60
Spleen	1.87	—	0.72
Stomach	1.10	—	2.20
Small intestine	0.90	1.2	1.50
Large intestine	1.20	—	1.87
Ovary	—	—	0.17
Uterus	—	—	0.60
Testes	1.20	—	—
Brain	0.75	—	0.90

Hair: Lead is deposited in large quantities in the human hair—much larger than what is found in the bones. Being a dead tissue, it has not received much attention in the hands of Kehoe and other pioneer workers and no detailed reference to the lead content of human hair is available in the current literature. In the course of our investigation on the lead content of human tissues (started under the auspices of the Indian Research Fund Association)

it has been found that the amount of lead in the hair varies to a considerable extent—the range being 3 to 508 mgm. per kilo of hair. Over 200 samples of hair representing both sexes and all ages and nationalities were analysed. The maximum amount of lead was found in the hair of Hindu women and children using vermilion adulterated with red lead (Bagchi *et al.*, 1940). Hair, unlike bones, does not appear to behave as a 'lead depot' of the human system but as a dumping place for lead, arsenic and other toxic materials (vide App. D) from where lead and other metals cannot be thrown back into the general circulation. Hair has thus been found to be a suitable material for detection of abnormal lead absorption in the system just in the same way as it is considered useful for the detection of arsenic in medicolegal cases. The following tables (Tables VIII and IX) would give an idea of the lead contents of different kinds of human hair and thereby indicate the usefulness of analysis of hair in suspected lead poisoning cases.

It would appear from the high lead figures in the hair of Bengalee women and particularly of Hindu women, as shown in Tables VIII and IX, that they

TABLE VIII

Lead contents of hair of different nationalities (about 200 specimens analysed). Figs. indicate mgm. of lead per kilo (Bagchi et al, 1940). Average figures given.

Nationality	Men	Women
Europeans (including Jews and Anglo-Indians)	20.8	18.4
Indians :	28.0	114.5
Bengalee Hindu	26.7	180.9
Bengalee Muslim	42.4	50.4
Punjabi	20.2	45.5
Madrassi	22.7	—
U. P. and Bihari	21.6	—
Other provincials (Parsee, Marwari, Oriya, etc.)	20.0	26.3

TABLE IX

Lead contents of hair of different shades of colour. Maximum amount of lead found in black hair and minimum in grey hair. Figs. indicate mgm. per kilo.

Colour of hair	Minimum	Maximum
Deep black (Bengalee women)	170.0	508.0
Brown, auburn and other shades (European)	9.0	16.5
Grey hair—containing 0 to 25% of black or brown hair (European & Indian)	3.0	21.0

imbibe considerable amounts of lead and are therefore liable to develop a chronic state of lead intoxication. The source of lead in these cases has been

found on careful investigation to be neither the water they drink and the food they take, nor the utensils and cosmetics they use, but the vermilion they apply to the hair parting. As the doses absorbed daily are infinitesimally small in this kind of exposure the poisoning is always of the insidious type, never producing the text-book symptoms. The fact that lead found in the hair is due to its actual absorption through the scalp and subsequent retention in this dead tissue, is proved by higher lead contents of the urine and faeces in these cases, as is usually met with where lead has been introduced into the system through the respiratory or other routes (vide Table X).

TABLE X

Lead contents of hair, urine and faeces of persons exposed to lead. Figs. indicate mgm. per kilo.

Case No.	Age, Sex, etc.	Occupation	Hair	Urine	Faeces	Remarks
70	Hindu female aged 21.	—	502	0·059	1·29	Apparently healthy using vermilion.
107	Hindu female aged 28.	—	315	—	1·05	Alopecia, using vermilion.
158	Hindu female aged 19.	—	128	0·02	1·04	Alopecia & abortions, using vermilion.
28	Hindu male aged 40.	Compositor, printing press	132	0·02	7·8	A suspected lead poisoning case.
67	Muslim male aged 30.	Compositor	121	0·144	4·56	A case of lead poisoning.
169	Hindu male aged 24.	Lead worker in a factory	241	0·04	230·3	Suspected malingerer for workmen's compensation. Note the faecal lead content.

Other signs and symptoms : Blue line in the gums and punctate basophilia or stippled red cells in the blood are believed to be characteristic signs of lead poisoning, but unfortunately both these signs are most unreliable, and even when present they do not indicate lead intoxication but only lead absorption.

Blue line : The term is a misnomer—it is neither blue nor a line. It is greyish black in colour and develops as blotches or as a series of dots along the free margin of the gums. It is best seen in the pink gums of the Europeans and not in the purple or dark gums of an Indian in whom the identification is difficult, more so if the gums are stained with *pan* juice, tobacco preparations, etc. The pigment causing the so called blue line is sulphide of lead produced by the action of H_2S , formed as the result of putrefaction of food materials in the interdental spaces or around the teeth, on lead present in the gum tissue as an albuminate. It is, therefore, not found in people who are toothless or who take much care of their teeth. Defective oral hygiene and pyorrhoea may, on the other hand, produce similar stains and they are frequently mistaken for the lead line. Why so much importance is attached to this sign is not understood. Even in Europe it is found in a small percentage of cases. Only 5.5 per cent of cases of plumbism among the type workers.

of Moscow developed this sign and that at an advanced stage of the disease and never earlier. "One is tempted to state", says Johnstone, "that it would improve diagnosis if this phenomenon had never been described".

Punctate basophilia or stippling of red cells : The general impression that stippled red cells are pathognomonic of plumbism is not true. They may be found in jaundice, neoplasms and many other diseases and also in poisoning from benzene, aniline, or any of the chlorinated hydrocarbons such as carbon tetrachloride, ethylene dichloride, acetylene tetrachloride, dichlorobenzene, etc., which are used as insecticides, fire extinguishers, dry cleaners, etc. The stippled cells are also of frequent occurrence in the blood of persons who are apparently normal and healthy, and who are free from any abnormal lead absorption. Stippling is usually found, if found at all, during the acute stage only and not at every stage of lead poisoning. It is conspicuously absent in the chronic stage, except occasionally during the stage of exacerbation produced by deleading treatment (Kehoe, *loc. cit.*). Several cases of classical lead poisoning with the text book symptoms such as wrist-drop, optic atrophy, violent colic, etc., occurring among the employees of printing presses and type foundries in Calcutta and admitted in the Medical College Hospital, did not show any punctate basophilic cells in their blood. Similarly in cases showing the signs and symptoms suggestive of the insidious type of poisoning, no stippled cells were ever found. Even if they were present, they would indicate, as in the case of blue line, lead absorption and not lead intoxication. The Moscow statistics shows that only 13.3 per cent of cases of lead poisoning developed punctate basophilia. As the cause of its occurrence and its significance are still obscure, it is safer to ignore it altogether.

'Wrist drop' or paralysis of the forearm : It is undoubtedly a characteristic sign of lead poisoning, but it should not be expected in the insidious type nor among the workers engaged in every industry connected with lead. Every trade has its preferential localisation according to the muscles most worked and fatigued, and wrist drop is, therefore, found among the 'hand workers'. Among the 'arm workers' such as painters, the biceps, brachialis, deltoids and shoulder muscles are commonly involved. The muscles of the thumb and hypothenar eminence are affected in the case of 'file workers' and so on. Every species of animal has its peculiar regions which are affected and in the human being it is the extensors of upper extremities which are usually involved (Leschke, *loc. cit.*).

The cause of lead palsy is not yet definitely known. It is, however, believed that the reaction of lead with the lactic acid of fatigued muscles to form lead lactate and the subsequent precipitation of insoluble lead phosphate in the muscles themselves and not in the nerves, account for the paralytic condition. According to this theory the degeneration of the nerves and neuritic changes are no longer tenable.

Arterio-sclerosis : It is described to be a common complication in advanced cases of lead poisoning, but the latest literature on this subject rules it out. Some authors are of opinion that it is simply a coincidental finding. "The reason that it is always described as such in all text books is that the authors of text books and medical articles frequently incorporate the opinion of their predecessors, assuming their scientific accuracy even though pathological evidence be lacking" (Johnstone, *loc. cit.*).

Vascular spasm : The spasm of the retinal vessels particularly of the central retinal artery, may cause temporary or permanent blindness. It is not of frequent occurrence and is found among those who absorb lead in heavy

doses. Coronary spasm produces angina pectoris. Simultaneous occurrence of large number of cases of angina pectoris has been reported among passengers of a steamer who had been accidentally poisoned by lead in food. Similar changes in brain vessels causing encephalopathy and in renal vessels producing contracted kidney have been known to occur among workers who happened to absorb lead over a very long time. Spasms of superficial vessels of the skin produce paleness, and of the hair-follicles produce 'falling out' of hair—the latter being of frequent occurrence among women.

Symptoms simulating other diseases : The usual signs and symptoms of the insidious type of poisoning, e.g., the dyspeptic symptoms, slight constipation and abdominal discomfort or slight diarrhoea, anaemia, lassitude, etc., are so ambiguous and simulate so many common ailments having no relation to lead, that the possibility of a correct diagnosis is always a remote one. The physician cannot be blamed for his inability to diagnose the insidious case as its occurrence is not expected and rarely suggests itself. The mistakes in the diagnosis of lead poisoning are often due to not expecting it. The dyspeptic symptoms which may be caused by indiscretion in diet, protozoal or helminthic infection of the gut, or other diseases, cannot be expected to be ascribed to lead if the physician does not know that his patient has been exposed to an abnormal lead risk. To think of lead as a possible cause for such ailments is obviously a far-fetched idea. Sir William Gowers stated in connection with diagnosis of obscure cases of nervous diseases with anomalous symptoms that "it is not possible to avoid error in such cases except by the habit of remembering lead as a possible cause in obscure cases".

As India is extremely backward industrially and as women, specially those belonging to the middle class and also those living in the country have nothing to do with any industry, nor do they get any chance of exposure to lead except perhaps to adulterated vermilion, the question of industrial or occupational lead poisoning never arises and the physician would naturally think of all other conditions except plumbism. Miscarriages and menstrual troubles which are frequently caused by lead poisoning are usually attributed to the specific infection, vitamin E deficiency or displacement of the uterus or something like that. The problem is further complicated by the 'selective action' of this element. Not only does it select a particular tissue or organ of the body, but it shows a preference to a particular individual of the family. This is explained in terms of idiosyncrasy, susceptibility or lowered resistance of the individual thus affected. Different persons under the same conditions of lead exposure may show marked variation in imbibing and retaining lead in the system and producing symptoms of poisoning, and the resistance of the same individual may also vary at different times (Monier-Williams, 1938). A latent or dormant case of poisoning with an apparently good health record may become a pronounced case after starvation, medication, shock, acute infection, disturbance of calcium metabolism, changes in diet, etc. (Lynch *et al.* 1934). The fact that the diet of an individual plays an important role in the absorption of lead and development of poisoning, has been experimentally proved by several workers. Milk, for example, retards its absorption considerably from the gastro-intestinal tract (Miyasaki, 1930). The bulky food of Indians and particularly of the vegetarians also retards absorption of lead from the alimentary tract. Similarly high calcium diet or low calcium diet with high phosphorus, exerts profound influence on the absorption of lead and its elimination from the system. In fact such diets have lately been recommended for treatment of lead poisoning. They bring about its mobilization from bones and possibly

from the reticulo-endothelial system, both of which are known to retain quite a large amount of lead introduced in the system.

Taking all these facts into consideration, we must realise the difficulties that stand in the way of diagnosing cases of lead poisoning, particularly of the insidious type which simulates so many common ailments. We should, at the same time, remember that a lead worker may get colic due to gall stone or urinary calculi, gastritis or gastric ulcer, chronic amæbiasis, hook-worm infection, or weakness, anaemia, constipation, loss of appetite and weight due to early tuberculosis, and in such cases there is the danger of an initial mistake being made by the physician in concentrating his whole attention on lead and ignoring the possibility of other diseases. In dealing with these cases 'the physician must never forget that one can have fleas *and* lice together'.

Before I conclude I would like to impress once again on the medical profession the importance of lead poisoning, particularly of the insidious type, and its implications. As rapid industrialisation is expected early and as the existing public health measures introduced for industrial workers are of primitive type, I put it forward as a plea for reorientation of the system of public health administration and medical education in this country, and for this purpose I feel tempted to place the following suggestions before the medical profession and the scientists in general for their consideration. I believe this is also the time most opportune for consideration of these suggestions by the Government as well.

INDUSTRIAL HYGIENE

ITS IMPORTANCE AND DEVELOPMENT

I stated in the beginning that with gradual industrialisation in India, cases of lead poisoning among the lead workers might greatly increase. The prevailing illiteracy and want of civic and sanitary consciousness as its corollary, and on the other hand, want of suitable technical and hygienic measures adopted by the employers concerned, are likely to accelerate the incidence of lead poisoning on a scale much higher than what actually happens in the West. It is not only the lead that is poisonous but dust containing other metals and silica and all metal fumes are also harmful, though not to the same extent as lead, to the health of the workers and also of the people living in places surrounding the factories. It has been established that the incidence of diseases, other than specific occupational diseases, is greater among the industrial workers than the general population and the expectancy of life of the industrial worker is less than that of other people. These facts have led the Public Health authorities in all civilised countries and particularly in the U.S.A. to develop a very important branch of the Science of Preventive Medicine, viz., Industrial Hygiene, an applied science to protect and improve the health of the workers.

Dust is stated to be the greatest curse of industrialisation and it has been recognised that the diminution of the dust hazard in all industries will result in a corresponding diminution of morbidity and mortality from tuberculosis and other respiratory diseases (Jacobs, 1941). A rapid development of the science of Industrial Hygiene should, therefore, be aimed at to keep pace with the rapid industrialisation of the country. Otherwise the health of the workers would deteriorate and the establishment would suffer heavy loss by way of workmen's compensation and inefficiency of the workers due to chronic ill health,

It has been the experience of medical men in charge of clinics dealing with occupational diseases that most cases of lead intoxication in the industrial cities of the U.S.A. are met with among workers in small factories in which no proper hygienic supervision is exercised. If that is the condition in the U.S.A. we might imagine what would happen to this country if lead industries were permitted to carry on unhampered by rules and measures devised to safeguard the health of the workers. It is interesting to note how an elaborate system of precautions is considered necessary for adoption in industrial concerns in which lead in some form or other is used. The following (taken from Johnstone) will give an idea of such measures as considered essential for the protection of the health of the people in and outside the works :

1. Hoods with adequate exhaust ventilation to be installed at any point where dust particles or fumes arise.
2. All mixing and shaking to be done in enclosed machines.
3. All powdered compounds to be transferred by means of adequate vacuum lines.
4. Work tables to be provided with grated tops, ventilated from below and equipped with small narrow troughs filled with water and attached to each side to prevent dust falling to the floor.
5. All inlets to exhaust ventilating ducts to be below the level of the nose, as far as possible, to prevent fine dust particles from being inhaled.
6. A chemical analysis of samples of air from various parts of the plant to be made at different intervals during working hours. A concentration of 1.5 mg. of lead per 10 cubic metres is a potential health hazard.
7. Employees in hazardous spots as found under 6 to wear respirators where movements are confined to a small area, forced draft respirators (fresh air from the outside) to be used. If exposure is to fumes masks to be provided with canisters charged with activated carbon. Respirators are only from 70 to 90 per cent efficient and must be inspected and changed frequently.
8. No dust allowed to accumulate on the floor.
9. Floors to be wet at frequent intervals.
10. All cleaning to be done with large vacuum lines. No sweeping.
11. To prevent the collection of dust on rafters, sills, etc., ventilating ducts to be installed, equipped with dust filters near the ceiling or in mid-air.
12. To avoid the contamination of outside air and surrounding territory, and as an economic measure, electrostatic precipitators to be installed in the stacks and flues.
13. The personal hygiene of the employees to be closely guarded. Locker rooms with showers, a lunchroom isolated from the plant, and change of overalls twice a day to be provided. Hands and face to be washed thoroughly before eating. No eating, chewing or smoking during working hours.

Establishment of a Central Research Institute for Industrial Hygiene: A comprehensive scheme for opening a Central Research Institute for Industrial Hygiene on American lines and smaller research laboratories for big industrial cities should be carefully drawn up along with the schemes for

postwar industrial development. Studying the diverse problems regarding the production, collection, identification, and determination of the quantity and toxicity of various industrial dusts, fumes, etc., and devising measures to safeguard the health of the workers and of the general public, will form the chief function of the Industrial Hygiene Institute. The work in such institutes being mainly chemical and highly technical in nature has to be carried out by chemists in collaboration with chemical and sanitary engineers. The Institute may also function as a post-graduate school for the training of chemists for employment in such laboratories to be started in future in large industrial cities.

INDUSTRIAL HYGIENE AND TRADE UNIONS

The Indian Trade Unions which look to the interests of the workers should be sufficiently conversant with the probable dangers to which the workers are exposed in different industries. The health of the workers *vis a vis* industrial hygiene should form an important item in their programme and they should always be on the alert and watch carefully if the measures and orders promulgated by Government for the prevention of industrial diseases and for improvement of the health of the workers are carried out by the employers. As some of the measures devised for the prevention of lead poisoning, for example, in certain lead industries are rather expensive and require structural alteration of work sheds and factory buildings, the employers would naturally try to evade them as far as possible and it is the alertness of the Unions that will be helpful in bringing about the desired result.

INDUSTRIAL MEDICINE

Creation of an Industrial Health Research Board : This will provide for intensive research on new problems of health and disease arising from the industrialisation of the country and initiate new departments of Industrial Medicine in large hospitals situated in industrial cities. This branch of medicine covers a very wide field including mental disease and applied psychology and is fraught with immense possibilities. The Industrial Medicine Department of the London Hospital has, for example, lately discovered that a form of hysteria may be caused by an organic derivative of mercury which is used as a fungicide, that signs and symptoms simulating Bright's disease are produced by Dioxan, an ethylene derivative used as a solvent for cellulose acetate (an ingredient of artificial silk, photographic films, etc.), and that polyneuritis producing paralysis is caused by another compound, triorthocresyl phosphate, used as a plasticizer. It is stated that over 20,000 people in the U.S.A. got paralysis of hands and feet by taking an alcoholic beverage contaminated with this compound. It is surprising how chemical industries can be held responsible for so many diseases. Apart from the fine chemicals mentioned above, the manufacture of heavy chemicals such as sulphuric acid, nitric acid, ammonium nitrate, etc., is also responsible for certain dangerous illnesses, and cases have been reported that workers feeling perfectly well throughout the working day died next day of pulmonary oedema after the inhalation of fumes containing oxides of nitrogen.

Training in Industrial Hygiene and Industrial Medicine : Considering the want of competent chemists with necessary training and experience in Industrial Hygiene Chemistry and of medical men with training and experience in Industrial Medicine, I feel the authorities should take up this question along with the schemes for various Technological Institutes and National Laboratories drawn up by the Directorate of Scientific

and Industrial Research in India, and depute a number of competent chemists and medical graduates (with higher qualification in chemistry) to the U.S.A. or U.K. for training in Industrial Hygiene and Medicine so that properly trained men may be available to start the work.

Raising the Standard of Teaching in Medical and Public Health Sciences :

(a) The present system of selection of candidates for admission in medical colleges is not suitable for the production of research workers. A certain percentage of the seats in a medical college should be earmarked for better types of students such as M.Sc.'s in Chemistry and Physics with brilliant academic records. The medical graduates with these qualifications are best fitted to grasp the newer ideas and developments in medicine, biochemistry and biophysics, and to carry out fundamental research with the help of Heavy Hydrogen, radioactive isotopes of phosphorus, calcium, iron, etc., in the metabolism of fats and mineral matters, in working out the action and course of drugs in the human system and other biochemical problems related to health and disease. The production of radioactive isotopes in the laboratory and their application in metabolic studies have changed the entire outlook of medical research. Knowledge in higher chemistry and physics is therefore an essential qualification and is helpful for research in all branches of medical science.

(b) The syllabuses prescribed for Hygiene for the M.B. or M.B.B.S. degree and for the Diploma in Public Health should be a little more explicit regarding the occurrence, absorption and toxicity of industrial poisons. Every Medical College and Public Health Institute should be provided with a museum and a miniature Industrial Hygiene Laboratory, so that the students particularly those who want to specialize in Industrial Medicine may be familiar with the more important apparatus and instruments required for investigations in Industrial Hygiene.

(c) Industrial Medicine should be considered as one of the subjects for postgraduate studies, and a Diploma in Industrial Medicine, as in the case of Tropical Medicine or Psychological Medicine, may be instituted in future when the necessary materials in the hospitals and other facilities for training will be available.

The subject is a vast one and the time at my disposal is limited. I am afraid I have already exceeded the time limit and I should therefore stop here. But before I resume my seat I must thank you once again for giving a patient hearing to my address.

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APPENDIX A

*Lead contents of normal human tissues (Indians)**Figures indicate milligrams of lead per kilo of fresh tissues (or parts per million.)*

No.	Tissues	Number of specimens examined	Quantity of lead found in the tissues			Remarks
			Mini-mum	Maxi-mum	Average	
1	Liver	9	0.31	0.82	0.57	
2	Kidney	8	0.37	0.71	0.50	
3	Spleen	5	0.30	0.52	0.36	
4	Small intestine	6	0.20	0.60	0.38	
5	Large intestine	5	0.30	0.68	0.55	
6	Stomach	8	0.20	0.60	0.41	
7	Heart	5	0.45	0.75	0.56	
8	Lungs	5	0.30	0.60	0.45	
9	Blood	6	0.11	0.45	0.24	
10	Thyroid	4	0.40	0.60	0.48	
11	Ovary	6	Nil	Nil	Nil	
12	Placenta	6	0.30	0.36	0.32	
13	Uterus	5	0.05	0.47	0.28	
14	Testes	4	0.30	0.40	0.34	
15	Brain	5	Nil	0.10	0.073	Nil, 0.075 mg., 0.09 mg., 0.1 mg. and 0.1 mg., respectively.
16	Muscle	5	0.14	0.70	0.33	
17	Skin	3	0.33	0.50	0.44	With its hair but without the subcutaneous fatty tissue.
18	Scalp	2	1.0	1.2	1.1	After complete depilation.
19	Fat	3	Nil	Nil	Nil	
20	Cartilage	5	0.45	0.25	3.25	From ribs and sternum.
21	Bone	8	6.8	39.3	15.8	Rib 8.2 to 8.5 mg. Tibia 6.8 to 14.5 mg. Femur 12 to 22.6 mg. Humerus 39.3 mg. Skull bone 14.8 mg.
22	Tooth	6	15.5	23.0	20.7	Maximum of incisors 19.0 mg. and of tricuspid 23.0 mg.
23	Hair	200	3.0	508.0	—	
24	Nails	3	11.3	12.7	12.0	

APPENDIX B

Lead contents of common Indian Foodstuffs

Figures indicate milligrams of lead (as Pb.) per kilo or litre as the case may be (or parts per million.)

A. ANIMAL FOOD

Meat (goat) ..	0.48, 0.47	Hilsa fish (<i>Hilsa ilisha</i>) ..	Nil
Goat's liver ..	0.18, 0.19	Votki (<i>Lates calcarifer</i>) ..	0.18
Goat's kidney ..	0.10	Crab (edible portion) ..	0.24, 0.20
Mutton 1.35, 1.2, 1.32		Sea fish—	
Mutton liver ..	2.3, 2.88	Tio (Plaico) ..	0.16, 0.12
Beaf ..	0.36, 0.35	Sole (<i>Cynoglossus lingua</i>) ..	Nil
Beaf liver ..	0.36, 0.42	Pomfret (<i>Pampus argenteus</i>) ..	Nil
Beaf kidney ..	0.2	Halua ..	Nil
Koi fish (<i>Anabus testudineus</i>) ..	Nil	Lady's finger (<i>Sillago sihama</i>) ..	Nil
Magur fish (<i>Clarias batrachus</i>) ..	0.06	Egg (duck's) ..	0.3, 0.28
Rui, rohu or rohit fish (<i>Labio rohita</i>) ..	0.32, 0.54	Egg (hen's) ..	0.24, 0.25
Shrimp (edible portion) ..	0.24	Chicken ..	0.03, Nil
		Lobster-fresh-water (edible portion) ..	0.08

B. VEGETABLES

Patol (<i>Trichosanthes dioica</i>) ..	Nil	Baigun or brinjal (<i>Solanum melongana</i>) ..	0.07
Karola (<i>Momordica charantia</i>) ..	Nil	Garlic ..	0.14
Radish ..	Nil	Cabbage ..	0.24
Lalkumra or pumpkin (<i>Cucurbita maxima</i>) ..	Nil	Cauliflower ..	0.2
Potato ..	Nil	Sweet potato (<i>Ipomoea batatas</i>) ..	Nil
Onion ..	Nil	Green papaya (<i>Carica papaya</i>) ..	Nil
Lao or louki or gourd (<i>Lagenaria vulgaris</i>) ..	Nil	Sajina danta or drumstick (<i>Moringa pterigospermum</i>) ..	0.08
Shim or ordinary runner bean (<i>Dolichos lablab</i>) ..	0.08	Carrot ..	0.24, 0.29
Puin sak (<i>Bassella rubra</i>) ..	0.2	Chalkumra (<i>Benincasa cerifera</i>) ..	0.26
Palong sak or spinach (<i>Spinacia oleracea</i>) ..	0.24	Bhindi or lady's finger (<i>Hibiscus esculentus</i>) ..	Nil
Natia sak (<i>Amarantus gangeticum</i>) ..	0.08	Lettuce ..	Nil
Karai sunti or green peas (<i>Pisum sativum</i>) ..	0.12	Colory ..	Nil
Dumur or green figs (<i>Ficus glomerata</i>) ..	0.32	Kaneh kala or green plantain (<i>Musa sapientum</i>) ..	0.2
Kalmi sak (<i>Ipomoea reptans</i>) ..	0.28	Thora, core of trunk of Musa paradisica ..	0.0
Beet ..	0.21	Betel leaf ..	Nil
Jhinga or ridge gourd (<i>Luffa acutangula</i>) ..	0.18	Jack-fruit seeds (<i>Artocarpus integrifolia</i>) ..	0.12

C. CEREALS AND PULSES

Rice, parboiled ..	Nil	Khesari dal (<i>Lathyrus sativus</i>) ..	0.16
Rice, sun-dried ..	Nil	Kalai dal or green gram (<i>Phaseolus radiatus</i>) ..	0.28
Motor dal (<i>Pisum sativum</i>) ..	0.12	Wheat flour—	
Chhola, boot or chana dal (<i>Cicer arietinum</i>) ..	0.24	Hand-ground ..	0.16
Moog dal (<i>Phaseolus mungo</i> var <i>aurea</i>) ..	0.16	Milled ..	0.28
Masoor dal (<i>Lens esculentum</i>) ..	0.12	Soya bean (<i>Glycine hispida</i>) ..	Nil
Arhar dal (<i>Cajanus indicus</i>) ..	0.04, 0.06		

D. FRESH FRUITS

Mango (<i>Mangifera indica</i>)—		Bael fruit pulp (<i>Aegle marmelos</i>) ..	Nil
Langra ..	0.06	Cucumber (<i>Cucumis sativus</i>) with skin ..	0.2
Fazli ..	0.08	Khorbuja (musk melon) (<i>Cucumis melo</i>) ..	Nil
Orange ..	0.32, 0.56	Lichi (<i>Lichi sinensis</i>) ..	Nil
Jam or jamun or black borry (<i>Eugenia jambolana</i>) ..	Nil	Golap jam (<i>Eugenia jambos</i>) ..	0.08
Guava (<i>Psidium gujava</i>) ..	0.24	Loquat (<i>Eriobotrya japonica</i>) ..	0.04
Ripe papaya (<i>Carica papaya</i>) ..	Nil	Coco-nut (<i>Cocos nucifera</i>) ..	Nil
Jack fruit (<i>Artocarpus integrifolia</i>) ..	0.13	Tal sansh or palmstone pulp (<i>Borassus flabelliformis</i>) ..	Nil

Grape	Nil	Sankh aloo (a tuber)	
Plantain or banana, Martaban variety		(<i>Pachyrhizus angulatus</i>) ..	0.05
(<i>Musa paradisiaca</i>)	N 1	Amra or hog plum (<i>Spondias dulcis</i>)	Nil
Apple (imported)	0.3	Tomato	0.28

E. DRIED FRUITS (MOSTLY IMPORTED)

Apricot	0.24	Dates (<i>Phoenix sylvestris</i>) ..	0.04
Pistachio (<i>Pistacia vera</i>) ..	0.3	Raisins	Nil
Almond (<i>Prunus amygdalis</i>) ..	0.56	Dried grapes	Nil
Walnut	Nil	Ground nut (<i>Arachis hypogea</i>) ..	Nil

F. SPICES, CONDIMENTS & MISCELLANEOUS

Ginger	0.08	Cummin seeds	Nil
Red pepper (<i>Capsicum annum</i>)	Nil.	Jowan or ajowan (<i>Carrum curvi</i>) ..	0.07
Turmeric (<i>Curcuma longa</i>) ..	0.4	Cinnamon	0.03
Betel nut (<i>Areca catechu</i>) ..	0.08	Common salt—	
Aniseed (<i>Foeniculum vulgare</i>) ..	Nil	Karkach (Aden salt) ..	0.42, 0.45
Coriander seed	0.06	Saindhab (rock salt) ..	0.25, 0.26
Mustard seed (<i>Brassica nigra</i>) ..	0.4	Liverpool salt	0.2
Black pepper	0.22	Bengal salt	0.4
Cloves	0.15	Sugar (country made) ..	0.00
Curry powder	0.32	Gur (from sugarcane) ..	Nil
Cardamom	0.23	Chutney (mango slice) ..	0.18

G. FATTY FOODS

Milk (human)—		Teel oil (sesame oil)	0.6
Bengali 0.16, Nil, Nil, 0.14, 0.17		Sialkanta oil (<i>Argemone mexicana</i>)	0.33
Punjabi	0.01	Ghee—buffalo (tinned) ..	0.56
European	0.04	Ghee—home-made from cow's milk	0.10
Milk (cow)	Nil	Butter (tinned)	0.43
Milk (buffalo)	Nil	Cheese (imported)	Nil
Rape oil (fixed mustard oil)	0.45	Khoa (a milk product) ..	0.024
Coco-nut oil	1.20, 1.32		

H. BEVERAGES

Tea (packed in lead foil) ..	2.4	Country spirit	0.026
Tea (packed in tins)	1.8	Whisky (country made) ..	0.027
Brandy (country made)	0.06	Aerated waters—	
Rum (country made, two different brands)	0.024, 0.057	Lemonade	0.004
Dry gin (country made)	Nil	Soda	0.004

I. COOKED FOODS, COOKED BY INDIAN METHODS OF COOKING

White bread (from imported white flour)	0.2	Mutton korma	1.34
Roti, chapatti (brown flour) ..	0.18	Potato and potol curry ..	0.32
Luchi, Puree (white flour) ..	0.30	Masoor dal (thick soup) ..	0.18
Cooked rice (cooked in earthenware handi)	Nil	Jilabi (with added yellow pigment)	0.20
Cooked rice (cooked in aluminium vessel)	Nil	Rabri	Nil
Hilsa fish curry	0.1	Rasogolla	0.03
Potato and rehu fish curry ..	0.38	Sandesh	Nil
		Biscuit (country made) ..	0.20
		Biscuit (imported)	0.03

J. SOIL AND WATER

Tap-water (Calcutta water-supply)	0.002	Tank-water (College Sq. tank) ..	0.001
Tube-well water (250 feet deep, Calcutta)	0.0015	Soil (Calcutta)	0.06
Tube-well water (250 feet deep, outside Calcutta)	0.0015	Soil (from a depth of 15 feet, Calcutta)	0.04

APPENDIX C

Lead contents of hair of members of certain Bengalee Hindu families where vermilion is used. More lead appears to be imbibed by the 'girl contacts' than by the 'boy contacts' in the same household.

Figures indicate milligrams per kilo.

Family No.	Relation	Age	Amount of lead	Using vermilion or not
I	Husband	35	19.5	Not using
	Wife	28	315.0	Using
	Daughter	4	277.0	Not using
	Son	1½	60.0	Not using
II	Husband	49	13.5	Not using
	Wife	40	503.3	Using
	Daughter (unmarried)	22	84.0	Not using
	Daughter "	19	122.0	Not using
	Daughter "	17	108.0	Not using
III	Husband	50	27.0	Not using
	Wife	39	72.0	Using
	Daughter (married)	21	502.0	Using
	Daughter (unmarried)	16	108.0	Not using
	Son	9	24.0	Not using
IV	Husband	34	34.0	Not using
	Wife	30	242.0	Using
	Brother	31	27.0	Not Using
	Sister (married)	30	302.0	Using
	Son	7	9.0	Not using
	Daughter	3½	74.8	Not using
V	Mother	28	284.0	Using
	Daughter	12	105.0	Not using
	Nephew	18	27.0	Not using
	Nephew	15	16.5	" "
	Nephew	13	16.5	" "
	Nephew	11	15.0	" "
VI	Uncle	28	24.0	Not using
	Niece (married)	24	162.0	Using
	Niece (unmarried)	19	100.0	Not using
	Niece "	14	116.0	" "
	Niece "	12	92.0	" "
	Niece "	10	104.0	" "
	Niece "	8	108.0	" "

APPENDIX D

Mineral constituents of human hair

(Bagchi and Ganguly, 1941)

	European girl aged 14. Brown hair	Hindu woman aged 25. Black hair	Mixed hair of 30 male adults, from a hair cutting saloon	Hindu male aged 28. A case of lead poison- ing
Carbon	44.03%	44.20%	44.60%	43.80%
Nitrogen	13.70%	13.68%	14.60%	14.20%
Hydrogen	5.58%	5.60%	5.40%	6.10%
Sulphur	5.80%	1.50% (?)	3.80%	4.20%
Phosphorus	0.065%	0.096%	0.08%	0.098%
Chlorine	1.98%	2.00%	2.00%	2.40%

Mineral constituents in Milligrams per kilo

Lead	21.0	284.0	47.7	241.0
Copper	64.0	62.8	108.0	28.8
Arsenic	2.4	2.2	2.2	1.8
Zinc	116.0	182.0	212.0	420.0
Iron	133.0	126.0	141.0	170.0
Manganese	28.4	25.0	38.0	46.0
Cobalt	14.2	16.0	18.1	16.4
Nickel	5.4	5.5	8.2	6.7
Calcium	212.0	188.4	208.0	267.2
Aluminium	26.0	26.0	32.0	36.0
Silicon	188.0	178.6	150.4	164.5
Bismuth	Nil	Nil	Nil	Nil
Antimony	Nil	Nil	Nil	Nil
Silver	Nil	Nil	Nil	Nil
Mercury	Nil	Nil	+	Nil
Tin	}	}	}	}
Magnesium				
Iodine				

SECTION OF AGRICULTURAL SCIENCES

PRESIDENT :—RAO BAHADUR V. RAMANATHA AYYAR, L.Ag., F.A.Sc.

PRESENT AND FUTURE POSITION OF COTTON

(Delivered on 5 January, 1946)

I appreciate the signal honour done by my colleagues in asking me to preside over the deliberations of the agricultural sciences section of the Indian Science Congress and I take this opportunity to express my grateful thanks to them.

I have chosen the present and future position of cotton in India as the subject of my address to-day. I am afraid that it will be of special interest comparatively only to a few. Cotton has been the subject of two previous presidential addresses of this section. Its improvement has been the subject of discussion and deliberation by many bodies like the East India Cotton Association and the Indian Central Cotton Committee, Bombay. My apology for selecting it is that my labours have been connected with this crop for over quarter of a century.

At the eleventh Indian Science Congress held at this city in 1924, late Sir B. C. Burt emphasised in his address^{*5} the need for producing more cotton in India and suggested for that purpose the study of the existing material and evolution of early maturing biotypes combined with higher productivity. He also laid stress on the importance of the study of the relationship between ginning percentage and lint length as well as of the physiology of cotton and on the necessity for team work. Eighteen years later, Dr. Nazir Ahmad surveyed in his presidential address²⁵ the progress made in the different cotton provinces of India and pointed out how the results of experiments did not reach the farmers rapidly. He dwelt on the competition of the synthetic with the natural fibres and suggested the formation of a panel consisting of representatives of different interests associated with cotton industry, to harmonise the claims of the two groups of fibres after surveying the position of production, demand and consumption in the home and foreign markets. He recommended amongst others, the adoption of suitable measures for developing home consumption and export trade, for lowering the cost of production of clothes, for increasing the production of medium and long stapled cottons and for the utilisation of short stapled varieties in non-textile purposes. In my present address I propose to deal with the present position of cotton production in India, the future trends and the steps, in my opinion, necessary for improving cotton farming, if India is to hold an important place in the cotton world.

THE PRESENT POSITION

Total production : In dealing with an international commodity like cotton, one cannot ignore, in a review of the present position in our country, the situation in other sister countries interested in cotton production.

* Numbers relate to literature cited at the end.

Amongst about 57 countries that grow cotton¹¹, the top six, viz., the United States of America, India, the U.S.S.R., China, Brazil and Egypt contribute ninety per cent of the total world output. It may suffice for the present to examine roughly the position in these countries during the period between 1915-1942 indicating only the pattern of changes caused subsequently by the World War II. In the United States of America, the total production fell between 1919 and 1924 as a result of the depredation of the boll weevil. In the next quinquennium, it improved as a consequence of the introduction of early maturing strains and the extension of cotton cultivation in the rich virgin soils of the Western States. The area restriction programme and price stimulating policies adopted by that Government from 1930 onwards brought down the annual production to the level of 12 million bales barring the bumper crop year 1937-38, when the total production including linters exceeded 20 million bales. That country continued, despite the drop, to be the foremost in cotton production. In the U.S.S.R. the production in 1919-24 was very low reaching as low as 43,000 bales in 1921-22. It improved rapidly in the subsequent years with the result that it is producing 4 million bales now and is on the way of challenging India to secure the second place amongst the cotton producing countries. Efforts are being made in that country to extend the growth in tracts beyond the limits generally deemed suitable for the growing of this crop. In China the production increased by more than two and half times during 1919-1937. Subsequently the war with Japan brought down the output. In Brazil, the production was only 39,000 bales in 1919-20. In 1939-40 it exceeded 2 million bale limit. In Egypt also there was increase in production during the interval, but it was only of the order of fifty per cent. Compared with these countries, India's production should be declared as practically stationary if variations due to seasonal conditions are allowed for. It fluctuated between 4.5 and 5.5 millions.²

Acre Yields : A study of the acre yields of lint is most revealing. A distinct improvement is noticeable in all countries barring again India. In the United States of America, it was about 135 lb. per acre in 1921 and in 1937 it was of the order of 280 lb. In the U.S.S.R., the acre yield was 162 lb. in 1932, 243 lb. in 1936 and 356 lb. in 1938. During the war period further improvements have taken place. In 1944. the average cotton yield is reported to have gone up by 4 cwts. per hectare (=2.47 acres) over that of 1943 by better organising labour and by utilising machinery more efficiently. Gaps in sowings are said to be filled up by planting seedlings raised specially in glass houses.⁸ China and Brazil also showed trends of increased production per unit area. In Egypt the acre yield of lint was of the order of 350 lb. in 1919-20. During 1925-30 the average was 426 lb. In 1935-40 it rose to 487 lb. and in 1942-44 it was 520 lb. In contrast to the above, the position in India was practically one of stagnation which is an important pointer. It was¹⁰

year	acre yield of lint in lb.
1922-27	.. 96
1927-32	.. 95
1932-37	.. 108
1937-42	.. 109
1942-43	.. 103
1943-44	.. 112

despite the fact that cotton was the first crop taken up for improvement several decades ago and has been a beneficiary of the East India Company,

of all local governments that succeeded it, and of the Indian Central Cotton Committee, Bombay since 1923. The slight increase noticed in 1932-37 was partly due to extension of the area under irrigation. Cases are, however, known where 900 lb. of lint per acre has been recorded over 30 to 50 acres in parts of Coimbatore and Ramnad districts with the aid of irrigation and with heavy applications of municipal rubbish, but in such areas the normal yields are only of the order of 300 lb. of lint. Similar records have been obtained in the Punjab and Sind

Quality improvement : There have been changes in the quality of cotton as well. In the United States of America the trend especially during recent years has been in the direction of increasing the average staple length as a result of (a) educating the growers and (b) the more exacting requirements of cotton manufacturers. In 1928-29 the proportion of cottons below 1¹/₂ staple to the total was of the order of 79 per cent. It fell to 67% in 1934-35 and to 57.1% in 1936-37. It dropped to 50% by 1940 and to 38% in 1941 and 1942. There has been definite discouragement to the spread of short stapled cottons. A similar phenomenon is noticed in other countries also. In Brazil, 90% of the crop in 1923-24 was only of 22-24 m.m. staple. In 1935, 99.3% of the crop had a lint length of 28-30 m.m. in addition to increases in production. In the U.S.S.R., 90% of the cotton now grown has an average length of 1¹/₂". In Egypt, however, there was a fall in average length with the reduction in area under Sakellarides; but there has been some improvement after the spread of the new types "Karnak" and "Malaki". India displays a similar improvement especially after the commencement of hostilities with Japan when the outlet for the surplus short staple cottons was closed. The proportion of cotton of below ³/₄" length to the total has considerably decreased. In 1928-29, 73% of the Indian crop was below ³/₄" staple. Five years later, the proportion was practically the same. In 1938-39, it fell to 63% while in 1942-43, the corresponding proportion came down to 40% due to the discouragement of short staple of cotton. It was further reduced to 38% during 1943-44.²⁰

When the yarn production in India is considered in terms of counts, a definite improvement in the spinning of counts higher than 30's is noticed except during the period of World War. 11.⁴

Counts in percentage of total production

	1-10s	11-20s	21-30s	31-40s	above 40s
1923-24	14	53	24	3	0.5
1928-29	12	47	33	6	1.5
1933-34	12	48	28	8	4.0
1938-39	11	43	26	13	7.1
1943-44	10	52	22	10	5.0 (war period)

Despite these developments, India is not yet self sufficient with regard to her present requirements of cotton. Ramiah²¹ has recently examined production in different lint length groups and showed that surplus production is mostly in cottons capable of spinning less than 10 counts and shortages are felt under styles of cotton with lint lengths of 1" and above. To meet the deficit in the latter group, lint from Egypt, Sudan, and East Africa is being imported every year in increasing quantities as shown below.⁴

Thousands of bales of 40 lb of lint

1923-24	1928-29	1933-34	1938-39	1943-44
91	23	222	315	509

Such a position is indicative of the immediate need for producing more of

medium and long stapled cottons and for reducing the area under short stapled cottons.

Utilisation of longer cottons : There has also been a change in the utilisation of longer stapled cottons. They are being used in all countries including India, to spin counts of yarn lower than they were used for in previous years. It is reported that in our country Egyptian cottons capable of spinning 60's yarn are now used in some mills to spin yarns as low as 16's. Such a phenomenon is being ascribed to higher strengths now demanded in war supplies and also to the introduction of subsidised payment to the users of foreign cotton. There is less of yarn breakage and waste percentage as a result of this change which has to be welcomed in the interest of this country, since it leads to the utilisation of more quantities of cotton. To make up for the loss sustained by the use of costlier cotton, spindle speed has been increased to reduce the labour cost.²

Increase in domestic consumption : Apart from this, the domestic consumption in various countries has increased as a result of the lack of transport facilities. In the United States of America, it was around 6.5 million bales of 500 lb. in 1929. The consumption is now well nigh 11 million bales. Cloth consumption per capita has increased from 64 sq. yds. in 1929, and 45 sq. yds. in 1934³⁷ to 70 sq. yds. in 1943-44. In India, the trends in domestic consumption including imported foreign cottons are

Millions of bales of 400 lb.

1928-29. 1933-34. 1938-39. 1943-44.

2.11 2.66 3.55 5.35

Per capita consumption has, on the other hand, shown a fall due to increase in population and in later years to exports of manufactured goods to war theatres.

1929

1934

1943

16.1 sq. yds. 15.3 sq. yds. 12 sq. yds.

Prices : This was a complicated topic in prewar days. Todd had reviewed the course of prices in his article "Twentyfive years of cotton prices".³⁴ He had shown there how the prices of No. 1 Fine Oomras compared with middling American fluctuated very widely owing to the changes in the demand of Indian cotton in Japan and to the coincidence of periods of bumper American crop with those of small Indian crops.

During the war period, prices have been controlled in all countries and free movement has not been possible. Consequently they had no international bearings.

It will be useful to compare at this stage the policies adopted in different countries in the fixation of cotton prices. In the United States of America, an export subsidy of 4 cents per lb. is being paid by Government from 15-11-1944 and shipping space is being found for such exports. It has been declared in Steagall amendment that this financial support will continue for two years after the World War II.¹⁷ The Commercial Credit Corporation of the United States of America has announced that Government would buy cotton middling 15/16" August delivery in Memphis at 22.15 cents and later deliveries at rates increasing by 5 points monthly until June, 1946. The Government's buying and selling programmes are expected to hold the prices during next season⁷. It may be noted that the rise in the cost of living in the United States of America was, in May 1943, only 25% more than what it was in August 1939, and yet the price of cotton is more

than double the prewar price. In Brazil the Government paid the grower Cr. \$66 per 32.38 lb. of lint in 1943-44¹⁰. There was clamour for increasing it to Cr. \$80 per 32.38 lb. on account of rise in general prices and in wages. It is reported that Government proposes to grant loans on 1944-45 crop at Cr. \$90 per 32.38 lb.⁸. In Paraguay the cotton growers were guaranteed a price of 2.72 cents per lb. in 1943 which was 0.28 cents higher than the price in 1942 and 0.68 cents higher than that in 1941¹⁰. In Egypt the British Government have agreed to purchase 1944-45 crop at 20% higher than that paid during the previous year on the ground that higher expenditure is being incurred on seed, fertilisers, labour and higher cost of living. It is since learnt that the increase in minimum price during the current year has been reduced to 10% due to the drop in the costs of production and the narrowing of the gap between the American and Egyptian cottons consequent on the American policy of export subsidisation. The British Government have also agreed to purchase the whole of East African cotton for a minimum period of three years or for the duration of war at 7.68 shillings per 100 lb. of seed cotton. In 1942 the growers got an average price of sh. 8.80 and in 1943 sh. 14. It may be mentioned in passing that according to a recent report, a large part of East African lint is being sold to India at 18d. per lb. of lint and the growers of such cotton receive less than half of what is charged to Indian buyers. According to the statement of the Secretary of State for Colonies, the estimated profits from the controlled marketing of cotton amounted to 2.4 million pounds during 1942-43 and 1943-44.⁸ In Northern Rhodesia the crop was purchased at $\frac{3}{4}$ d. per lb. of seed cotton, ginned, baled and sold at Gatooma at 9d. per lb. of lint. In Nigeria the British cotton growing association, acting on behalf of His Majesty's Government, purchased seed cotton at 1.4 d. per lb. The price has been raised to 2.7 d. for 1944-45 cotton. In Tanganyika the basic price for 1945 crop was raised to 14 cents per lb. of seed cotton.

In India the history is different. As mentioned previously a subsidy of Re. 0-8-0 per lb. was being paid by Government from 15-11-1943 to the manufacturers of cloth from foreign cotton. This rate was reduced to 0-6-0 per lb. in the case of cloth manufactured from above 30's yarns spun from East Africans and intended for export. For clothes with warp counts of 30's and over and reed 56 and over, an allowance of 4 annas per lb. of yarn for actual imported cotton used is being given.* Further, floor and ceiling prices were fixed by Government for medium stapled cottons. In 1943 the floor price for $\frac{3}{4}$ " Jarilla was fixed at Rs. 400/- per candy of 784 lb. In 1944 the floor price of this cotton was reduced to Rs. 350/- and in the case of some other cottons, the reductions were even more. This will work out to a little less than two times the prewar price at a time when the cost of all primary commodities has risen by 250 per cent. This situation forms a striking contrast to the conditions prevailing in the premier cotton producing country—the United States of America. The main arguments adduced for lowering the floor and ceiling prices were that the clothes should be made cheaper, that more area should be brought under food crops and that this measure would check inflation. It was even stated in some quarters that the decrease in cotton acreage would not affect the economy in view of the large surplus stock remaining in the country. It was also reported that Government intended to reduce the floors further in 1945. Several protests were made. The Indian Central Cotton Committee urged in two resolutions that the floors should be raised and not reduced as contemplated. Sir C.B. Mehta^{22,23} had made a strong plea in two separate pamphlets as well as

* It is learnt that the payment of subsidy has been withdrawn now,

on the floor of the Indian Central Cotton Committee against the cuts in the floor prices. He put forward in them forceful arguments for raising the floor and for reducing the spread between the ceilings and the floor. It was also urged that the concessions granted for users of foreign cotton to spin counts lower than 40's should be abolished. It is thus seen that the position in India has been made complicated and against the interests of the cotton grower. It is to be remembered that a rise in price is followed by a slow rise in price in the market where growers sell their kapas while a fall in price is immediately felt by a rapid decline at an accelerated rate, which condition hits the grower always disadvantageously. This phenomenon is present even in advanced countries. The position in our country is worse.

Technological improvements : We may now pass on to a study of the present position in technological developments. The tendency has been to increase the efficiency of output as a result of modern equipments introduced in many countries by manufacturers. Cotton mills are tending to become more and more automatic especially in the United States of America. Speeds of operation have been increased by improvements in the long draft roving and also by the introduction of paper bobbins. In 1927, 32 million spindles were employed in the United States of America to produce 8.8 million square yards of cloth. In 1940, less than 23 million spindles could spin yarn sufficient to produce 9.6 million square yards of cloth. The average operative period per active spindle rose from less than 3,000 hours annually in 1925 to more than 4,000 hours in 1939. Further as pointed out by Dr. Nazir Ahmad in his presidential address, many improvements in finishes like pre-shrunk and crease-resisting finishes, and in printing like the introduction of resin pigment printing, have been effected. Experimentation in dry cleaning to replace cloth scouring has been completed. Electrocoating of textiles for decorative purposes has been developed. In British Isles mule spinnings are gradually being replaced by ring spinning. A Commission presided over by Mr. Justice Evershed has been appointed to reform staffing and machinery to the benefit of the employer and the employee, to improve distribution arrangement and to extend double shifts. It cannot be said that in India equally rapid developments are on foot, although it can be conceded that some improvements in the manufacturing technique have been effected in some of the progressive mills.

Competition from synthetic fibres : Another significant feature to which attention was drawn by Dr. Nazir Ahmad is the rapid development of the synthetic fibres which bids fair to dethrone "King cotton". A useful note on the present situation was prepared recently by Dr. Ahmad for consideration by the Indian Central Cotton Committee. The rapid progress made especially during the war period in the production and utilisation of these fibres has become a matter of great concern to those interested in the future of cotton production and consumption. The artificial fibres especially the staple fibres are already spoken of as Enemy No. 1 and it is predicted that a fierce battle with artificial fibres is inevitable in the near future. The world's rayon production in 1942 was of the order of 3.5 billion lb. equivalent to 8.25 million bales of cotton. The price of staple fibre is quoted now at 14 d. per lb. equivalent to Rs. 610 per candy of 784 lb. for any staple length desired by the consumer—a price much lower than the current prices of important long staple cottons. Being fibres made under easily controllable conditions, reductions in prices may reasonably be expected when their output increases as a result of cessation of hostilities and when further improvements in the manufacturing processes are introduced. It may be

pointed out that the minimum limit to which the cost of production of cotton in the United States of America can go down in the near future is estimated to be 10.5 cent per lb. which is equivalent to Rs. 270 per candy of lint. It may not be long before the staple fibres are brought down to this price level under normal peace conditions. That industry is employing a large number of research workers with the object of improving the quality and cheapening cost of production. Many of the defects previously noticed in these fibres have already been removed. Their liability to lose strength when wet, the proneness of their yarns to damage, their poor durability, their tendency to deteriorate after washing, their low resilience and the limited range of counts that can be spun from them, are all being closely examined with the object of eliminating such defects. Rayon yarns of high tenacity capable of standing exceptional wear and tear are now being used for the manufacture of parachute cloth and tyre cords. The new kind of fibres is now found to resist crushing by footstep and abrasion and possesses more elasticity and non-fading qualities.¹⁴ The artificial fibres also possess as a class certain merits over natural fibres. They have uniform staple with no neps, seeds and foreign matter with the result that spinning waste in yarn production is less. Clothes made of these have better appearance and are more popular with people of low income. Their manufactured goods entail less shipping cost. They can be produced irrespective of changes in weather conditions and in spaces much smaller than that required for the production of an equivalent quantity of raw cotton. Their prices do not fluctuate much—a very favourable point for manufacture of fabrics. The advent of these fibres has no doubt increased the total fibre consumption. It has to be said, however, they are replacing rapidly other textile fibres. Garments and household apparel which were previously made entirely of cotton are now being manufactured by mixing cotton with these fibres resulting in the reduction of the total cotton consumption. In addition to these there is also a keen competition between cotton and non-textile fibres in the manufacture of clothes. Jute, rubber, plastics, paper and even glass are invading more and more into what has been the domain of "King Cotton".

Summarising the present position, it will be clear that though India continues to hold the second rank in total production, it has not shown as much development as other countries like Russia, Brazil, and China. Its average acre yields have not appreciably increased and continue to be the lowest. The improvement in average staple length is much below the advancement noticed in other countries though good increases are shown in the proportion of medium and long to short stapled cottons. The technological improvements effected do not compare favourably with those in other competing countries. Indian cottons like those in other regions have soon to face very keen competition from synthetic fibres.

TRENDS

Effects of plan of self sufficiency : Amongst the various lessons learnt in the recent war, the need for making each country self sufficient in most of her requirements is an important one. Different methods were adopted to reach that ideal. In countries where cotton produced was in surplus, a programme of restriction of the area was followed. Several measures were taken up to increase domestic consumption. In some countries plans for the increase in the spinnage were prepared and carried out in part. In Brazil a provision has been made to increase the spinnage from 2.5 to 6 millions. If a need for the export of surplus is still felt it is likely that

export subsidies may be increased. It is said that the Government of Egypt have decided to reduce the cost of ginning, pressing and transport, to cancel the export tax and to abolish the compulsory inland war risk cover with the ultimate object of helping exporters of raw cotton.⁸ In countries where the cotton production is below the sufficiency level, arrangements have been made to increase the area under cotton and to instal plants for the production of synthetic fibres. The latter trend is noticed even in India which has an exportable surplus. A mill was started recently in Travancore for the manufacture of rayon. It is also reported that some industrialists in Bombay will be starting a rayon mill with the help of American manufacturers. In tracts where cotton cannot be grown due to climatological limitations, more plants have been set up to produce cotton substitutes. It is estimated that Germany alone has now factories to produce raw material equivalent to at least three million bales of natural fibres.⁹ It is said that by 1952, the world's output of rayon will be approximately equal to three fourths of the present total cotton production.

Apart from these, countries which can produce cotton at very low costs will strive to extend the cultivation of cotton. The comment of *Nyasaland Times* on the conditions in Africa is of interest in this connection.¹⁰ It comments that the price of 1.5 d. per lb. of seed cotton which itself should be considered low, paid to the grower is satisfactory and observes that African produced crops require not high but stabilised prices. These indicate that cotton has yet more crises to pass through.

Further great advances in ideas and techniques are anticipated as a result of impact of different nations during the period of war. Wants will run on new lines. There will also be changes in tastes. Dame Fashion has shifted now from Paris to New York. That will mean that American products will catch the eye better and will be bought with greater avidity for some time after each change. Rayon with its inviting appearance will undermine the hold of cotton. It is therefore necessary to have a flexible policy regarding the future developments in cotton so that a switch over if found necessary can be effected in the shortest time.

In this connection mention may be made of a line of thought existing in some quarters of our country. It is considered by such persons that in India the day when cotton will be replaced by artificial fibres is far off. I for one do not share that opinion. I am inclined to think that in our country where many are not prepared to don coarse clothes to increase the consumption of Indian grown cotton which is not wanted anywhere, few will care to wear clothes made of cotton only. Whatever is less expensive and possesses at the same time inviting appearance will become the favourite of the common people provided the durability is not lowered. This condition will also be overlooked by those who can afford. With the improvements that have already taken place and others yet in store in synthetic fibres, garments made of mixtures of natural and artificial fibres will become cheaper. One should be prepared for the heavy imports of the latter category into India which will eventually work against the interests of cotton.

Rise in standard of living : There is however one saving feature in the above outlook and that is the result of a rise in the standard of living on cloth consumption. All the treatises on the postwar economic development in India emphasise on the need for improving the standard of living. When earning capacity increases, more money will be spent on clothes. Western and Eastern countries show a similarity in this respect. It is reported that in Czechoslovakia, cloth purchases trebled as the average expenditure rose by 125 per cent. In China the

expenditure on clothes increased three-fold when the total family earning doubled. In Japan the cloth purchases rose by 150% with the doubling of the total expenditure. In India the investment on clothes by the bulk of population may not rise in the above proportions. It may, however, be mentioned that the target fixed per capita consumption of cloth by the authors of the People's Plan³ is 50 yards as against the present consumption of 15 yards. The National Planning Committee and Bombay planners²⁸ have fixed the minimum requirement of clothing in India at 30 yards per person, while Professor Agarwal¹ recommends in his "Gandhian Plan" a per capita consumption of 20 yards of cloth per annum provided that the durability of such cloths is one year. Since the normal life of cloth in India, especially with the people of low income using the same piece over and over, is only 6 months, it will mean the consumption of 40 yards per year per head. Taking, however, the lowest target of 30 yards the total cloth consumption in India will be nearly 12,000 million yards equivalent to the production of 7.5 to 8 million bales of cotton. This will give an allowance of nearly 2.5 million bales of extra cotton over the present production or equivalent quantity of synthetic fibres.

One more point has to be borne in mind. It is likely that free trade is not likely to begin for some years to come and a policy of Empire preference will continue. Great Britain is already emphasising the need for rapid expansion of exports and reduction of imports. That may mean greater importation of finer and better finished goods into India. The cottage industries may have a set back. Suggestions regarding international agreement on production and export of raw cotton, levy of import duties, change in Rupee, Sterling exchange have also been made. In fact an international cotton advisory committee has been formed and this has appointed a special study group to go into the question of regulating production and export of cotton in each country. It is stated that a world cotton conference will be convened. But all recommendations are contingent on policies adopted by several Governments which are often conflicting and are not easily influenced by the members of study group.

THE FUTURE

It is thus manifest that raw cotton has to be produced at rates competitive not only with cotton growers in more favourably placed countries but also with its machine made substitutes. The consideration of this point cannot be disposed of by recommending the abandonment of its cultivation at a stage when its price falls below the pre-war level of cost of production. Nothing will be more suicidal.

Cotton growing a necessity in India: Agriculturally, cotton has many favourable points. It is not a "burden of long hours and excessive toil". Its cultivation is simple. The plant can stand great fluctuations in rainfall which is a common enough phenomenon over all the rainfed tracts of India. The crop affords scope both for a better distribution of labour and for the greatest employment of family labour for the peasant cultivator. It gives greatest returns per man hour to the grower. It is the only crop that can be sown in certain periods of rainfall. For example in Bellary the biggest cotton growing district of Madras, no crop other than cotton can be grown if it rains in the first fortnight of September. Its produce is easily marketable in spite of wide variations in quality. It can stand storage for a long time. It possesses more than any other commodity the attributes of gold in settling international balances. The cotton textile industry is preeminently suited to agricultural countries like India where labour is still not skilled and trained,

If such a crop is to be lost, the agricultural economy of the country will be greatly disturbed without any possibility of finding a suitable substitute. Cotton has to, and will occupy, a high place amongst agricultural crops in India. All planners cannot escape taking that as a basis for further economic development so long as agriculture continues to be the foremost industry in India. It is, therefore, vital to see that cotton is produced in this country. It is with this perspective that cotton agronomists, breeders and growers should strive to achieve results. There are no two opinions in this regard. It is necessary at the same time to cease growing it on marginal and sub-marginal lands where little response to ameliorative and better farming methods is noticed.

It will be desirable to view cotton and synthetic fibres as complementary and not competitive, and frame the future programme. Cotton varieties which will mix well with the artificial fibres and which will supplement qualities lacked by the latter, should alone be encouraged for large scale cultivation. Such a step will keep up the demand. It is reported that in Japan development of artificial fibres has not hit the textile industry since 1935.

Various suggestions like reduction in the cost of cultivation per acre, better utilisation of cotton seed and its products, and betterment of marketing, transport and ginning technique have been made in connection with the survival of cotton in times of low prices. I wish to confine myself for the present mainly to the first factor. Before that aspect is considered it will be useful to discuss here two important points. Those relate to the class and species of cotton which India should grow in future.

Short versus long stapled cottons : With regard to the first point, the Indian Central Cotton Committee has never missed opportunities to take steps to increase the area under long and medium stapled cottons in India. It has always lent financial support to all schemes with that goal. It convened a special meeting in November, 1944 to consider this question amongst others, in connection with the planning of cotton production. As short stapled cottons are being grown in excess of the demand, and considering the need for growing more food grains, it was decided as an important short term measure to curtail its production during 1945-46 and 1946-47. The committee, however, postponed the consideration of the long term aspect of planning for production. Now the war is over and all countries are busy-ing themselves in putting into order the available machinery for the manufacture of clothes. It is imminent to think of future plans for our country. In Madras it was recommended by the Post-war sub-committee on Textiles that a fair price should be guaranteed to cotton growers and that, while taking steps to discourage the growing of short stapled cottons, a textile mill should be set up in the Ceded Districts to utilise the short stapled cottons produced in that area out of necessity. Recently Dr. Thoria, while discussing the competition between cotton and synthetic fibres, suggested to the the Indian Central Cotton Committee that future efforts should be directed towards developing short stapled cottons in India by increasing their yield so that they could be used in the manufacture of synthetic fibres if that would be more paying than the growing of long stapled cottons.³³ There is some force in this argument. It has to be admitted that short stapled cottons are hardier, better evaders of drought and pests, and are capable of producing higher yields under adverse conditions and earlier in duration than long stapled varieties. They have a higher ginning percentage, and as a class this characteristic is more prominent in Asiatic cottons than in American. As a matter of fact, it can be stated that good lint length and high

ginning percentage go ill together in indigenous cottons and that the magnitude of the negative correlation is so high that the evolution of a bio-type combining both features is more a lucky accident than a result of careful application of plant breeding methods. Under Indian soil and climatic conditions, it is much easier to develop the area under short stapled cottons. It may be of interest to mention here that India produced two centuries ago a higher proportion of medium stapled cottons. It was the high prolificity of the short stapled types coupled with encouragement given by the East India Company in developing its trade with China that was responsible for the spread of short stapled cottons of "Bengals" group. The replacement of Bani by the short stapled Oomras and the spread of Mungari cottons in the Western areas in Madras presidency are all due to the high productivity of these varieties. Government of Madras have been enforcing Cotton Control Act in parts of Tinnevely areas for more than a decade with the object of suppressing the cultivation of the short stapled "Pulichai" cotton and have employed special staff to detect and penalise the growers of the unwanted "Pulichai" and yet it cannot be said that that cotton has been completely driven out of that area. During the period of war, special measures had to be taken by the Government of Madras and Bombay to reduce the area under short stapled varieties. These are evidences to show how if left to natural conditions the short stapled varieties tend to oust out bio-types of high quality. It is not unlikely that short staples will withstand the onslaught better than the long staples in the battle between natural and synthetic fibres. My feeling in the matter is that the time has come to change our outlook. It takes seven or eight years to see the effect of alterations in the cotton breeding policy. Since rapid strides are likely to occur in the production of textile fibres during that period in other countries, it is wiser to think of precautionary steps in our country from now. No harm will be done by being prepared for the worst. Longer stapled varieties should be made more productive. They are to be produced in ever increasing quantities in India till their prices fall below the cost of their production. Since they are generally less hardy and respond better to manuring and irrigation, their cultivation can be restricted to irrigated areas where they will continue to be remunerative for a longer period. For the rainfed areas where seasonal conditions have a dominant influence on yield level, short stapled types will be better suited to stand competition. As such it should not be considered a retrograde and unorthodox step to direct cotton breeders in rainfed regions not to neglect breeding of heavy yielding bio-types irrespective of their fibre length. Isolation of more productive types can be aimed at concurrently both in the short and medium stapled groups with a provision that no short stapled strain should be released for distribution without the express permission of the Indian Central Cotton Committee. The goal should be to evolve more and more heavy yielding cultures with the idea of determining the maximum potentialities of production in each tract so that they may be handy to spread them when a change in cotton situation demands such a step to safeguard the interests of growers.

New World versus Old World cottons: The second point is to determine which of the two big groups of cottons, viz., New world and Old world, should merit greater encouragement in the years to come. At present only 38% of the total cotton production in our country belongs to the exotic group. These are generally less hardy and generally unsuited to black soils on which more cottons are being raised in India. They also demand higher standard of cultivation. They have a longer maturation period despite earlier flower production and are more susceptible to pests and diseases and to changes in

climatological factors. Their merits are that they have greater potentialities for yield, for fineness of fibre and for responding better to irrigation. Their kapas are easier to pick when good opening types are considered.

I consider that if India is to retain her rank amongst the cotton growing countries of the world in the future, she will have to switch over to an increasing extent to exotic varieties. This opinion is, however, divided on account of the shortcomings of American cottons. But it has to be stated that cultivated Americans being of the 52 chromosome group as compared with 26 chromosomes present in the indigenous cottons, would possess greater possibilities of producing larger number of combinations with desired qualities. It is the lack of variability in the existing material in India that has precluded this cotton from producing better bio-types suited to black soils. These were imported more than a century ago without any heed to the value of biological variability and had lost the little variability present in them during the period of acclimatisation. It is well known that "upland" cottons are being grown in the black waxy prairie region of Texas under rainfed conditions, on the stiff clayey soils of Sudan with irrigation and on the black earths of the U.S.S.R. Even in India, certain uplands like Būri and Dharwar Americans are being grown on the black soils. These are good evidences of American cottons proving suitable to rainfed black soil. The problem is the getting of proper type of cotton with high botanical variability. Trends in other countries are towards replacing indigenous cottons by Americans. Countries like U.S.S.R., Persia and China which were having large areas under Old World cottons have already replaced and continue to replace them by American cottons. In India too similar tendencies are noticed in the Punjab and Sind in spite of the greater susceptibility of American cottons to "Tirak" phenomenon. There is no need to get alarmed at this suggestion. What is urgently needed is to arrange for expeditions of cotton botanists to Mexico, Venezuela, Columbia and Brazil where American cottons are reported to be found in a wild state under all kinds of environment of soil and climate with the sole purpose of collecting material for further development in India, either for hybridisation or otherwise. It is a matter of common knowledge how the U.S.S.R. sent a number of expeditions to various parts of the world and how with the aid of their collections they have been able not only to produce higher yielding cottons but also to extend their cultivation to areas declared unsuitable for cotton by earlier biologists. It is learnt that the Indian Central Cotton Committee has this subject in the list of the future programme of development. It may, however, be urged to take early steps in that direction. The expeditionists might also collect high productive bio-types even of short staple so that they may be used for the production of rayon, if their cultivation proves remunerative under changed conditions.

Maximum potential in cotton.: Methods of cheapening cost of production can now be considered. Amongst the several direct and indirect methods leading to that goal, the indirect one of increasing the unit yield is admittedly the most important. Willcox³⁵ while developing agro-biological laws has shown that the theoretical maximum potential yield of a cotton crop is 4.6 bales of lint per acre and the highest production known is 3.7 bales of 500 lb. i.e., 80% of the theoretical potency. The maximum that has come to my knowledge in India is only 900 lb. Willcox has indicated that the maximum quantity of nitrogen or potash or phosphoric acid that can be 'resorbed' from soil in one growth cycle by the most powerful of living plants under best conditions of growth is 318 lb. per acre and that the maximum limit of yield of any specified plant variety can be determined

by dividing 318 by the normal percentage of nitrogen content of the dry plant weight. The maximum yield is then derived by making suitable allowance for their nitrogen present in parts of plant other than those forming yield of a crop. Taking Rs. 150 the highest pre-war acre cost of cotton production in the world which happens to obtain in Egypt, the highest cost of producing 1 lb. of lint on the basis of maximum potential of 4.6 bales of 500 lb. will be 1.04 annas equivalent to Rs. 51 per Bombay candy of 784 lb. for Egyptian cotton. This gives the minimum level to which cotton growing can be kept on under best of conditions.

Factors of high production in other countries : It has already been stated that India occupies the bottom-most place in the scale of acre yields amongst cotton growing countries. It will now be helpful to enunciate the factors that have led to better yields in other countries. In Egypt which records the highest average yield per acre, the factors favouring high productivity are rich silty soil, application of heavy doses of manure, intensive cropping with legumes, irrigation, high humidity and planting on ridges to prevent water logging.²⁷ In the U.S.S.R., collective farming system and development of irrigation have contributed much to the rise in yield levels. In collective farms, machinery and the best scientific methods are brought together and utilised. The state supplies finance, machinery and advice by agricultural experts. Fifteen tons of bulky organic manures and 800 kilogrammes in each of nitrogeous and phosphatic manures are being applied to a hectare of 2.47 acres. During the war period the rate of mineral fertilisers was reduced from 250 lb. to 18 lb. per acre while that of organic manure was raised to 19 tons per hectare. The land is ploughed four times with tractors. Sowing is done with tractor drawn implements. The crop is irrigated eight times and the seeds of best yielding strains are used for planting. Steps are taken to distribute with lightning speed the seeds of newly evolved strains to the farmers. Breeders responsible for the isolation and evolution of more remunerative strains are given by the state a proportion of the profit as bonus. In China, the production was increased by the distribution of improved seeds, assignment of improved quotas and by granting subsidies for digging wells. In the United States of America, the average yield has arisen after the introduction of Agricultural Adjustment Act owing to the diversion of worn out and depleted lands that were growing cotton previously, to soil building crops. Cotton is at present raised on best soils. The lands are prepared better than in former times. Tractors are used for the levelling of lands. Manures are being applied more frequently as top-dressing. Only better yielding and quicker maturing strains are used for planting. Single variety communities are created in larger numbers. Government rural settlement organisation loans to farmers sufficient funds for the purchase of livestock, implements and fertilisers. In addition to this, the soil is rich and the distribution of rainfall is good. The labour is better trained and transport facilities and handling methods are excellent. In Brazil the advantages are abundance of rich virgin soil, favourable climate, expert supervision regarding supply of seeds of improved strains and classification of lint, favourable distribution of population and improved transportation in certain areas.

The factors that favour the high record of acre yield in other countries are rich soil, favourable climate, intensive manuring, use of high yielding strains, irrigation, adoption of cost cutting agricultural practices. There is nothing novel in these except collectivisation. The first two are peculiar to each country and are therefore unattainable in all countries to the same degree.

Limitations of yields in India : In contrast to the above conditions, Indian soils have been long under cultivation, Nearly 50% of the area is

completely dependent on rainfall, and weather hazard is very high. It may be mentioned in passing that in India the coefficient of variability of acre yields in rainfed Oomras, Dhelleras and Westerns cottons is 19, 22 and 23 respectively as against 14 in the rainfed areas of the United States of America. Amongst the irrigated Indian cottons, the coefficient is 28 for the Punjab American, 37 for Sind American, 13 for Cambodia, 24 for the Punjab and Sind *deshi* as compared to 16 exhibited by the Egyptian cottons. This is most revealing since irrigation which lowers weather hazard is not very effective in the case of the irrigated cottons of the Punjab and Sind due perhaps to the operation of "Tiraq" factor which reduces yield of kapas in certain years by premature opening of bolls and to the damages done by jassids and whiteflies.

The economic condition of the cotton grower in India is low. State aid is not on a scale obtaining in other countries. Manuring is not generally practised even in irrigated areas. Fiftyfive per cent of the total crop is from inherently low yielding varieties. Although improved strains have spread over 54% in 1942-43 and 48% in 1943-44 of the total cotton acreage, its effect is not felt appreciably in raising the average yield level. A scrutiny of the disposition of acre yields of the different varieties through many years reveals that definite yearly increases are noticed in Sind *deshi*, Sind Americans, Cambodia, Broach, Gujarat Dholleras, but these are offset by the high seasonal fluctuations and the low yields observed in the Westerns, Oomras, Gaoranis and Kumpta cottons. It may be mentioned that improvement of yields by the growing of the improved strains is of the order of about 10 per cent. The effect of adverse seasonal conditions is on the other hand of the order of 20 per cent. Naturally the results of the efforts made by the Indian Central Cotton Committee and the several local governments in the spread of high yielding strains are not perceptible in the yearly curve of India's combined acre yield. It has to be remembered that in no other cotton growing country, the growing area is as widely scattered as in India. Wide weather fluctuations are bound to exist in all years in this wide stretch of land spreading over many latitudes. This is in contrast to the condition in the cotton belt of the United States of America, which extends from east to west and has much lower seasonal variations.

Another handicap is the slow spread of the high yielding strains in areas to which they have been found to be suitable, despite the fact that most of the cotton growers do buy their seeds every year. This is due to the absence of sufficient number of reliable seed depots in the interior villages. Most of them depend on the village seedsmen who sell on credit seed of very doubtful purity. A still another disability is the lack of animal power to make the best use of the timely rainfall. The sowing rains are received suddenly within a short period and seeds of a variety of crops have to be sown before the soil moisture dries up. Sometimes preparatory cultivation and sowing have to be taken up on successive days precluding the farmers from completing the sowings within the desired period. If the farmer happens to be tenant or a small owner, he has to satisfy the urgent needs of the neighbouring influential Zamindar before he takes up his own sowings. These hazards and liabilities make the Indian agriculturist indifferent to the small ten percentage advantage to be gained by the use of better strains.

Promotion of soil moisture : I shall now pass on to the consideration of individual factors of production. It is a matter of common knowledge that amongst them provision of adequate soil moisture holds the top place. It is necessary to bear in mind that in that supply, the time factor is more important. If water can be provided before the onset of "boom" stage

ie., before the plant is not too far advanced in age, the response of the plant to the supply is the highest. It is on this account centres with easily commandable water supply scores over those with uncontrollable distribution of rainfall. All measures that will go to promote timely supply of soil moisture should, therefore, be given priority over others. Bombay planners and post-war reconstruction committees have already included in their proposals, construction of new dams, excavation of new canals, tanks and wells. The existing tanks have also to be deepened with the aid of bulldozers. In addition to these, a survey of subterranean water supply especially on the red soils where the soil drainage is better and where irrigable water can be had should be made either by geologists or by successful water diviners.

It is often said that spotting underground water supplies with the aid of water diviners is unscientific and is not always supported by facts. I have known cases where water was struck on the Central Farm, Coimbatore, in a majority of sites located by a water diviner. Water scarcity was thus got over very easily on the farm. That is simply a question of employing the best men available, after testing with the aid of drills, their efficiency in divining in twenty or thirty cases. It will be a worthwhile proposition for the State to sink wells in the sites successfully selected by the diviners, instal engines and supply water at favourable rates to promote crop production in areas where canals and tanks cannot be had. The principle that in all Government schemes of irrigation the total water cess collected should give adequate rate of interest on capital invested, should be given up in consideration of the ultimate advantages to be derived in enabling agricultural produce to stand competitive prices. When scarce resources are utilised to maximise production they should get high priority. In the black soil areas, the subterranean water is usually unfit for irrigation and the water table is generally low. It will be useful in such areas to impound water flowing in the rivers and the surfacedrainage in tanks. The drawbacks in the latter are that either the water impounded may in course of years become saline or the bunds may frequently breach through deep cracks. But these are not unremediable. The water impounded would help to raise the water table in the neighbourhood enabling the extension of the area under fodder and irrigable crops. Even in the case of cotton, mixture of crops like cotton and *Setaria italica*, cotton and paddy under rainfed condition can be raised more successfully where soil moisture happens to be high. In the irrigation research station opened at Siruguppa for the study of effects of irrigation on black soils, derivatives of crosses between Asiatic and American cottons evolved at Surat have proved more successful than strains of acclimatised American cottons. It testifies to the possibility of evolving by breeding, bio-types suited to soils with fairly high moisture content. Controlling the surface run off in black soils by throwing embankments at suitable gradients along the contours also aids in improving soil moisture in such areas. But there are many snags to be got over. In years of heavy rainfall these embankments do more harm than good. Sowings are delayed. Large areas are sometimes damaged by breaches. Another direction by which soil moisture can be used with advantage is the hastening of sowings. Experiments at cotton breeding station, Coimbatore, have shown that even under irrigated conditions sowings in September increased the cotton yield by 30% as compared to sowings in October. Every farmer knows the differences in the growths of the same crop sown in the morning and in the evening. The limiting factor in these cases is the capacity of the animals to work at a stretch. This handicap can be overcome by the designing of light motors run with petrol, kerosene or liquid fuel.

These engines should be capable of working the existing drill and harrow of the black soil farmer over wet soil so that sowings can be completed within the shortest time without losing the benefits of seasonal rains. It is reported that in Texas state of the United States of America cotton is sown throughout the night with the aid of powerful lights for the purpose of utilising the soil moisture.

Plant food factor : Plant food factor stands second to moisture in rank in increasing production. What is needed now is information on the nature of response of each soil to different kinds and levels of manures. Experiments in Madras have shown that manuring the crop previous to cotton is more remunerative than manuring cotton directly. Sometimes in some soils the effects of manures are not perceptible. The causes for the above behaviour have to be determined. It may be that in black soils much of nitrogen is lost as a result of their alkalinity or it is leached out earlier than the development of roots or the soil bacteria utilise the nitrogen much faster than the plants. The Indian Central Cotton Committee is financing, after a review of the available information by Dr. Panse, schemes in several provinces for the comparison of the effects of ammonium sulphate and groundnut cake in different levels of soil fertility. Dr. Panse while reviewing the results of recent experiments has concluded that the degree of response to nitrogen is strongly related to the inherent soil fertility, rich soils responding highest and poor soils giving little increase as shown below.

Response to nitrogen in lb. of kapas per acre

Station	Average yield level	20 lb. N.	40 lb. N.	60 lb. N.
Akola	622	159	264	370
	455	162	174	148
Koilpatti	612	103	155	207
	477	68	107	123

This is an important finding since it indicates where manuring is likely to be remunerative in Indian soils. More trials are proposed to be conducted along these lines.

Since the remunerativeness is also dependent on the relationship between price per lb. of kapas and the cost of one lb. of nitrogen and since the price of kapas is liable to drop very low, it is essential to see that cotton grower gets his manure at the lowest possible cost. In other words, if cottons of India are to be sold at competitive rates, it is necessary to reduce the cost of manures to the lowest limit. It is to be watched if the proposal of manufacturing ammonium sulphate in different parts will bring down the cost to the required level. In case this does not happen the position of cotton cultivator will be unenviable.

Improved strains : Improvement of yield by the growing of more productive strains stands low amongst factors of production, as the average level of increase is only of the order of 10 to 15 per cent. It is, however, more popular on account of its being the least expensive amongst methods. Its chief merit lies in that it demands no addition to cost of cultivation, no change in the crop husbandry practices and no modification in the existing agricultural economy. The isolation of more productive strains is however a long range work involving intensive studies over a period of seven or eight years. Even then to get a combination of all desirable characters like yield per acre, high ginning percent, long fibre length, is mostly an accident owing to the lack of precise knowledge of the inter-relationship between these multiple

factors in different genic back-grounds and of the potentialities of the parents for the production of progenies of the desired type. The only safety of the breeder lies in the largeness of numbers of bio-types handled and in the wide variability of the material. It is towards furtherance of this object, expeditions to Mexico and other American countries where American cottons are found under wild conditions have been recommended earlier in the paper.

Utilisation of hybrid vigour : Another direction in which augmentation of yield can be sought is the exploitation of hybrid vigour. It is a matter of common knowledge that in cotton hybrids particularly fertile interspecific hybrids like *G. hirsutum* x *G. Barbadosense*, and *G. arboreum* x *G. herbaceum* are very vigorous, prolific and early. Some of the cotton growers in South India are fully alive to this factor. In Tinnevely district the cotton seed produced in a few villages like Chinmayyapuram and Chandragiri commands as high a price as for seed cotton. The secret of their popularity lies in the seed containing a high proportion of Karunganni (*G. arboreum*), Uppam (*G. herbaceum*) crosses. These plants are prominently vigorous, tall and carry a good number of bolls. It may be mentioned here that the hybrid vigour is exhibited to a high degree only in certain combinations. If arrangements could be made to determine the type of combinations fruitful for raising yields to the maximum extent and to produce such hybrids every year for seed purposes the yields can be advanced easily. The snag in this method is the high cost involved in obtaining hybrid seeds, which can however be reduced considerably by smearing moist earth, prior to the opening of the flower, over the staminal column without injuring the stigma and dusting the pollen of the second parent before noon. Women can be easily trained in this operation. In some trials made at Coimbatore, the cost of production of seed sufficient to sow an acre worked out to Rs. 5. The enhancement of yield brought about by the sowing of hybrid seeds was of the order of 40 per cent, as seen in the subjoined statement. The cost of seeds can be brought down appreciably if family labour is employed. It may further be cut down if the crossings are done in periods and tracts where boll setting is high.

yield in ozs per cent. of land

<i>G. arboreum</i> parent	..	42.75
<i>G. herbaceum</i> parent	..	19.51
Hybrid seeds	..	59.29
S. D. mean	..	±2.6 ozs.

Search for low nitrogen absorbing types : Willcox has indicated yet another method which has not yet been tested and exploited fully by the cotton breeders. He has enunciated that the absolute limit of yielding power in all agrotypes can be represented by the formula $318/n$ where n stands for the nitrogen content of dry weight of the particular genotype. It follows therefrom that the smaller the value of ' n ', the higher will be the yielding capacity. This statement appears rather puzzling and irreconcilable with the observed increases in yield following applications of nitrogeneous manures. Dutt and Krishnaswamy* consider that so far as sugarcane grown in Coimbatore are considered the relationship pointed out by Willcox does not hold good. Nevertheless it will be a useful clue for breeders to spot out early and really good productive types. Investigations have to be started to determine how far Willcox's dictum will be valid in the case of cottons. There is, however, one important point to be considered and that is with regard to the size of seed. Since lint is an append age to the seed coat which

* Paper contributed to 33rd session of Indian Science Congress.

encloses the chief nitrogen containing component, viz., the embryo, selection of types with low nitrogen content will lead to a reduction in the size of embryo, which will be prejudicial to the germination of the seeds and growth of seedlings. Cotton seedlings are generally very delicate at the time of germination. If the drive for greater productivity is to result in poor germination of their seeds and poor growth of seedlings at a stage when they have to contend against adverse conditions of climate and soil, the prospect of getting a good stand of plants which forms one of the important component of yield over a unit area, will be seriously jeopardised. It is, therefore, necessary to see that the nitrogen reducing tactics are not pushed beyond the limit that will prove highly prejudicial to the germination and the early growth of seedlings.

Variety trials : There is still another line of study worthy of pursuit. Professor Vavilov had advocated the conduct of a series of trials all over the country with varieties or strains evolved in different cotton regions with the object of utilising to the maximum extent the potentialities of the existing material and thus save time. This plan was carried out in the United States of America as well as in China⁴, with beneficial results. It will eventually afford greater scope for the establishment of plant communities with similar features which are valuable in getting higher prices. I am aware that such trials have been taken at a few centres in India. My plea is that these should be taken up on a larger scale.

Cotton plant is comparatively a lover of high temperature. Its productivity is heightened if its developmental and maturing periods synchronise with periods of high temperature. As a result crops that pass through North East monsoon period, when the temperatures are lower, are relatively poorer yielders. In Madras, Cambodia cotton sown in March-April yields higher than that sown in September-October. If the sowing of cotton is shifted to summer season in tracts where lift irrigation is feasible, the acre yields can be increased appreciably, merely as a result of change of growing season. But in such tracts it is essential to see that no cottons are grown during cold weather. Else that region will become a good breeding ground for cotton pests and diseases throughout the year.

A great disability in the present day cotton growing is its long duration of six to eleven months. It often does not permit the growing of a second crop within an agricultural year. If its total duration can be reduced without any adverse effect on the acre yield, it will be a great advance. The introduction of Co. 3 and Co. 4 cottons in Ramnad and Tinnevely districts of Madras was welcomed on the score of their shorter growing periods. In the U.S.S.R. and in parts of the United States of America, evolution of strains with 120 days duration has been reported. It should not be difficult to breed such bio-types in India too. They will be very helpful in irrigation farming.

Bonus to the breeder : One important point may be emphasised in this connection. Evolution of better yielding strains is the product of creative art. If that is to be stimulated to produce the maximum effect under the existing conditions, it will be profitable to whet the profit making instinct amongst persons capable of isolating new bio-types by giving a share of the likely profits. The breeder and the agronomist may be guaranteed a certain percentage of profits when they succeed in the production of better agrotypes. When U.S.S.R., where the formulation of "classless state" is the goal, adopts such a policy, the case is stronger for granting such premia to discoverers of better yielding bio-types in a country where capitalisim and vested interests have a big sway.

Again measures are necessary to take the seeds of improved strains to the doors of the cotton growers without any loss of time. It is stated that one of the factors that aided the quick increase of yield in the U.S.S.R., was the steps taken by that Government to spread the seeds to the growers with lightning rapidity. The distribution has to be arranged either by the grant of suitable loans or by exchange of seeds of better strains with the ryots' inferior seeds.

Collective farming : Another factor of production which has recently been adopted successfully in the U.S.S.R. in the raising of yield levels is collective farming where production is not left to the entire care of individual producers, but is planned carefully to utilise all the available material and human units to the maximum extent. Collectivisation enables pooling of the resources like implements, cattle and man power, for the improvement of the weak farmers and for the betterment of poor soil. The State supplies the commune with first class agricultural machinery like tractors, drills, harrows and harvesters. These enable the farmers to crop larger areas in proper time, to manure all lands according to a given regimen, to use seeds of heavier yielding strains and to maintain the soil fertility for a longer time. As a result, cost of production per acre is reduced simultaneously with enhancement of yield. Based on such results there is at present a universal cry for the adoption of collective farming in India. No doubt such a move will be very helpful in raising yield levels. In fact therein lies the quickest and surest way of attaining the object. But before recommending it, many of the premises responsible for the success of the Russian experiment should be fulfilled. The most important of them is the elimination of unhealthy development of selfish profit making motive. The all absorbing instinct for selfish acquisition which debases the worker has to be controlled by various measures. Unemployment which follows mechanisation has to be guarded against. It is reported^{18a} that in that country everybody is secure of getting profitable employment at all times. There is no fear of scarcity or glut in the market affecting the prices of commodities. None is to fear about under or over work, and wage reduction. Everyone does his best which factor is the keynote for the successful working of the collective farming. When these conditions do not exist in India it is not possible to achieve the desired results. It is futile to expect, knowing human nature as it is to-day, individuals co-operating earnestly to reach a common goal. As a first step in that direction beneficent legislation compelling people to take up certain measures should be introduced. The State should take the lead to eliminate weak points in the collectivisation. Till then collective farming will remain a far cry.

There is one other direction which will lead to improvement of yield. Many fields are foul with deep rooted weeds which compete with crops for soil moisture and plant foods. The State may own tractors and lend them, as in the U.S.S.R., to the farmers for the breaking of the new land and for quickly cleaning the fields of deep rooted weeds. It is a welcome sign to see many provincial governments taking steps in this line. In a similar way the State may stock at convenient centres small equipments along the lines described previously for the rapid sowing of crops.

Collective cropping : It has been suggested in some quarters that collective cropping where neighbours combine to raise the same crop will prove more profitable in India. It is no doubt true that such a system will lead to economisation in watching the crop, in regulating water supply and drainage, in maintaining seed purity and in better marketing of the produce so that all the available factors of production may be utilised to the best

extent. But even here the selfish acquisitive instinct regarding the use of family labour, traditional cropping in individual fields, stands in the way of persuading individual farmers to adopt a uniform policy. Even in the case of paddy lands where conditions are most suited for the practice of collective cropping, farmers find it hard to co-operate. The basic factor in all these as is well known, is the regulation of beneficial practices by the State coupled with the granting of all concessions needed for the proper working of the system and development of a will to work together.

Model farms : It is often said that yields can be appreciably increased by the adoption of improved methods and that model farms should be opened to demonstrate such methods. It is not clear what these protagonists of improved farming methods mean by them. It can be stated categorically that many of the items like introduction of costly and complicated implements without state control have serious limitations. The scope for the use of mould board ploughs is very much limited particularly on black soils. The introduction of machine drills and barrows will not prove remunerative under the present conditions. There is no need to have model farms to demonstrate the use of these implements. Government farms are necessary only to carry out research on subjects pertaining to each region and to gather data to aid propaganda. It has to be borne in mind that research moves slowly and that is its inherent drawback. It is well known that the Indian farmer will be able to produce as much as his compeers in other countries provided he has adequate water supply for timely irrigation and enough manure and provided he is not burdened with indebtedness and with implied and expressed rights of the landowner. As a matter of fact what cannot be achieved on a State farm can be worked out successfully on peasants' land. For instance a particular pattern of agriculture alone will prove remunerative in each tract. To determine the combinations that will go to make up that pattern is not feasible on Government institutions; because many small points furthering production which are possible in peasant crop husbandry cannot be developed in such institutions where all labour including supervision is hired.

Award of prizes to farmers : It is wise in these circumstances to encourage private farmers to produce maximum yields by granting them substantial prizes. It is reported that in Italy, the wheat yields were very low prior to the advent of fascism. To improve the yield, rich prizes were offered by the State to the producers of the largest acre yield in each district. In the two seasons after the announcement, the response was poor. But the movement gained momentum and new records of acre yields were established soon. The yields gradually rose from 87 bushels to 122½ bushels to the acre which were considered to be world's record for wheat yield. It is stated that the achievement of the maximum limit production was only secondary and that the important result of the competition was the knowledge which many farmers gained in the technique of growing better crops which had enabled Italy to wipe out the wheat deficit.³⁶

In the U.S.S.R., production of higher yields of cotton was stimulated by giving higher prices to the growers. In the irrigated regions, farmers producing 2 metric tons per hectare were paid 180 to 200 roubles per 100 kilos (=220·5 lb), those producing 3 metric tons per hectare got 230 to 250 roubles according to quality when the price of raw cotton was 110 roubles per 100 kilos. In the unirrigated tracts, the growers of 500 kilos per hectare got 151 roubles per 100 kilos. For those who produced 700 kilos, the rate was 238 roubles and for growers of one metric ton per hectare, the rate given was 307 roubles per 100 kilos.³⁸ Nearer home in Bombay presidency we

may remember that the production of sugarcane was stimulated by offering a prize of Rs. 3000 to the growers of 100 tons per acre over a minimum area of 30 acres. It is reported that the acre yields in those farms continue to be high even now, testifying to the effect that the agriculturists of those areas have learnt the secrets of producing high tonnages. It will be well if the Indian Central Cotton Committee comes forward with an offer of big prizes to the producers of maximum yields in each tract, so that information on the conditions necessary for getting highest yields may become available for passing it on to all cotton growers. It has to be realised that crop husbandry is yet an art notwithstanding the great strides made by research workers in disclosing many of its secrets. It is also not to be forgotten that the intense specialisation sought in modern science is a great handicap. The new staff as stated by Russel^{12a} are not very proficient in the practice of agriculture. Many small tips which help in the development of high yields and in making crop raising more remunerative are either overlooked or not known. It is well that the problem of determination of the best pattern of agriculture in each type of land is left in the hands of traditional artists by giving them all facilities and inducements. When that knowledge is secured, it is a simple matter to spread it to the neighbours so that maximum production can be obtained from our lands. To further stimulate production by farmers, a national cotton week can be arranged and persons who create new records in maximum yields can be dubbed with an attractive appellation like Cotton Chief or Knight.

Cotton picking : Another direction where improvement is possible is to increase the quantity of kapas picked per day. In the unirrigated tracts of Madras presidency where indigenous cottons are cultivated, the average weight of kapas picked per day per labourer ranges from 20 to 50 lb. depending on the variety of cotton. In the case of irrigated Cambodia cotton it may reach the level of 100 lb. This figure forms a big contrast to those given in South Africa and the United States of America. In the latter country, a cotton picker is reckoned to pick normally 300 lb. per day. The importance of this item in the cost of production can be realised better if it is remembered that the pickers are paid in kind and 1/6 to 1/10 of the crop is lost to the grower. Appreciable improvement can be effected by the cotton breeders in this respect. The new agro-types evolved by them should have their bolls maturing uniformly within a short period and opening widely to facilitate quick picking.

I have come to the end of my song. I have indicated a few lines of work which will be helpful to cotton in winning the forthcoming battle of fibres. I have laid emphasis only on the aspect of reducing the cost of cultivation leaving out points on storing, ginning, baling, marketing and technological improvements. It will be evident therefrom that new knowledge and data are to be gathered on many directions. Research on many lines are to be intensified by employing more workers. Botanical expeditions will have to be arranged. It has, however, to be stated that research is always slow and strengthening that activity alone will not lead to the desired results which are required rather quickly. Introduction of beneficial legislation is an important *sine qua non* for the rapid development of acre yield. A survey of the subterranean water has to be carried out and wells have to be dug. Supply of more electric energy and of more manures at reduced rates, opening of tractor and light motor stations for reducing the cost of preparatory and sowing operations, making farmers collective minded, distribution of seeds of improved strains at a greater speed, will all help to reach the goal quickly. The consumer also must take up his share of responsibility. He

must be prepared to use more of coarse cloth if the bulk of cotton growth in India is not to be a mill-stone around the neck of Indian cotton trade.

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SECTION OF PHYSIOLOGY

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THE AUTONOMIC NERVOUS SYSTEM AND THE HYPOTHALAMUS

(*Delivered on 5th January, 1946*)

It is my first duty to express my deep sense of gratitude to you, my colleagues, for the great honour you have conferred on me by electing me to preside over the deliberations of the Section of Physiology of the thirty-third session of the Indian Science Congress. That, certainly, is a great honour to a man of science. Being fully conscious of the responsibility placed on me and also of my limitations, I feel diffident of my ability to shoulder the responsibility of this onerous task. With your kind co-operation and help, however, I shall try to carry on my duty to the best of my ability.

The part which the autonomic nervous system plays in regulating the functions of the organs is very often underestimated. This prompted me to take up this subject for my address today. During recent years much research has been carried out on this subject ; but as the time and space is limited, I do not propose to give a detailed account of the various influences that this system exerts upon our body and on the numerous functions of the hypothalamus so far as they are connected with this system. I am going to deal only with a few of the more important functions which are under the control of the hypothalamus.

HISTORICAL

The first suggestion of the autonomy of the sympathetic nervous system is traceable in the work of du Petit (1727) in which he observed the effect of stimulation of the cervical sympathetic on the pupil. Jacque Benigne Winslow introduced the term "sympathetic", and the term "vegetative nervous system" was first used in 1800 by Marie Bichat who developed the idea of the relative functional independence of the two nervous systems of the organism. The idea of the interdependence of the two systems regulating the organic and vegetative life was outlined by Claude-Bernard (1852) who showed the part played by the sympathetic system in regulation of processes such as secretion of the glands and vasomotor functions. Onodi (1886), differing from the opinion of Bichat regarding the independence of the sympathetic from the cerebro-spinal system, showed that the sympathetic cells originated from the cerebro-spinal system. Towards the end of the last and at the beginning of the present century new light had been thrown by the work of Langley and his school and the work of Gaskell on the vegetative nervous system. Gaskell (1916) demonstrated the connection of the sympathetic peripheral mechanism with the central apparatus, and with the nerve cells in the spinal cord and pons, and thus destroyed the principle of the anatomical independence of the sympathetic

system. He conceived that visceral nerves originated from homologous columns of cells in the central nervous system; that these columns were broken by the origin of the nerves to the limbs; and that these nerves radiated from the central nervous system in the cranial, thoracic and sacral outflows.

The presence of synapses in the path of fibres was first revealed by Langley (1890) by utilising the action of nicotine, which ultimately paralyzes synapses which are present in the ganglia. Every fibre of the sympathetic system forms one synapse with a nerve cell at some point in its course, and this is the only break in the continuity of the fibre. Injection of nicotine prevents the impulse passing along the nerve fibre from the spinal cord to the ganglia via the rami communicantes but does not affect the course of the impulse from the sympathetic ganglia to the periphery. Thus each fibre-path is composed of two sections—a fine medullated nerve fibre, arising in the spinal cord and passing out to a ganglion, the pre-ganglionic fibre, and the non-medullated sympathetic fibre arising from this ganglion and continuing onward to its peripheral distribution, the post-ganglionic fibre. The name “autonomic nervous system” was given to this system by Langley, who divided the whole system into tectal, bulbo-sacral, thoracico-lumbar and enteric (plexuses of Auerbach and Meissner). The tectal and bulbo-sacral outflows were grouped by him as “parasympathetic” and the thoracico-lumbar as “sympathetic”. The preganglionic fibres of the parasympathetic system pass near to their final destination before terminating in synapses which, as shown by the nicotine method, are situated in peripherally-placed ganglia, whereas in the sympathetic system the pre-ganglionic fibres of the white rami pass to the sympathetic chain, and may travel up or down in it for one or more segments, giving off branches on the way, ultimately ending by synapses with many cells in one or more of the lateral ganglia.

Langley noted the antagonism between the sympathetic and the parasympathetic systems. The sympathetic system is catabolic and is concerned with the dissimulation of energy, while the parasympathetic system is anabolic, and is concerned with the assimilation of energy. A delicately balanced co-ordination of the sympathetic and the parasympathetic activities is required in maintaining the uniformity of condition of the body. Examples of this kind of co-operation are many, such as, the exact and delicate adjustment of the body temperature, local blood supply, etc., for the maintenance of which a highly integrated reaction involving both divisions of the autonomic nervous system is called for.

TRANSMISSION OF NERVE IMPULSE

The liberation of a chemical substance at the nerve endings was first suggested by Du Bois Reymond (1877) and afterwards by Elliott (1904-05) but they had no direct experimental evidence to support this. Loewi (1921) was the first to demonstrate that the vagus acts on the frog's heart by producing a chemical substance which inhibits it, and it is now generally believed that this substance is acetylcholine and is produced in the immediate vicinity of the vagus ending when it is stimulated. It is also known that if a loop of the intestine whose vagus nerve has been previously stimulated be removed and suspended in Ringer's solution, then its contractions are greater than those of another similar loop whose vagus nerve has not previously been stimulated. This suggests that, during intestinal activity, a substance liberated by the vagal endings augments the contractions of the intestinal loop. After injection of a large dose of eserine and without

any nerve stimulation, Feldberg and Rosenfeld (1933) demonstrated the presence of an acetylcholine-like substance in the portal blood of an animal with intact intestines. Dale and Feldberg (1934 a) produced evidence of a manifold increase of acetylcholine by the stimulation of the thoracic vagi, adequate to cause contraction of the stomach wall. A similar substance was found in the venous blood, or perfusion fluid leaving the resting stomach when eserine was injected or added to the perfusion fluid; during stimulation of the vagus there was a fourfold increase in the amount of this active substance.

Dale (1933) suggested that neurones may be classified as adrenergic or cholinergic, depending on the nature of the chemical substances produced at their terminals, and this suggestion received direct support in the studies of many other workers. Hellauer (1939) observed that adrenergic nerves contain little or no acetylcholine, and it is interesting to note that they contain, on the other hand, a relatively large amount of cholinesterase. The parasympathetic post-ganglionic fibres, or the pre-ganglionic autonomic fibres at their synapses in the ganglia or in the suprarenal, are classed together as cholinergic, whereas the sympathetic post-ganglionic fibres are adrenergic. The sweat glands in man, although they have sympathetic innervation, are cholinergic in function, their behaviour to the action of drugs being like that of the structures supplied by the parasympathetic. These are stimulated by the administration of pilocarpine, are paralysed by atropine but are unaffected by adrenaline. Dale and Feldberg (1934 b) showed that excitation of the sympathetic fibres in foot-pads of cats, perfused with warm, oxygenated Locke's solution containing a little eserine, produced sweating and the appearance of acetylcholine in the eserinated fluid perfusing the paw.

With the progress of work along these lines, the question of transmission of nerve impulse, and of the liberation of the chemical transmitter at synapses in the autonomic ganglia, and of the release of sympathin and acetylcholine at the neuromuscular and neuroglandular junctions has attracted much attention in recent years. A purely electrical theory cannot explain all the data satisfactorily. The autonomic nervous system is not a continuous entity. Its structural discontinuity is supported by studies on degeneration by Gibson (1940) and Kuntz (1938, 1940). In studying the microscopical appearances of the synapse, Gibson observed that *boutons terminaux* and *boutons de passage* were similar to those in the central nervous system, but their number and size were very small; the largest number seen in one cell and its processes was only thirteen, compared to hundreds counted in one ventral horn cell in the spinal cord. After section of the cervical sympathetic trunk, Gibson also traced degenerative changes in the *boutons*, from the second day, in the superior cervical ganglia, but the ganglion cells themselves were not affected by the degeneration of the preganglionic fibres. The first sign of regeneration appeared in eleven days and reappearance of the *boutons* was first seen fortyfour days after the operation when the ganglion recovered its functions. Hinsey *et al* (1939) showed that in cats after true preganglionic sympathectomy of the fore-limb there was regeneration of the preganglionic fibres in 36–61 days. Feldberg and Gacklum (1934) demonstrated that stimulation of the cervical sympathetic in the cat caused the liberation from the ganglion of a substance which was identified as acetylcholine. They also showed that injection of acetylcholine into the perfusion fluid flowing to the ganglion produced a contraction of the nictitating membrane. Mendel and Hawkins (1943) working on rats under constant experimental condition and measuring

the diameters of their pupils have shown that there is partial or total abolition of direct light reflex when cholinesterase preparations are injected. This fact indicates that this reflex is dependent on the presence of acetylcholine at some point or points in the path of transmission of the nerve impulse. Feldberg (1943) demonstrated that acetylcholine was synthesised by the superior cervical ganglion, cervical sympathetic, vagus, phrenic nerve and motor roots. He showed this by cutting these nerves into small pieces very gently with scissors and then incubating them for one or two hours in buffered solution containing eserine. Feldberg attributed this property to the intactness of some structural part of the tissue, because it was lost or greatly reduced when the mechanical destruction was carried too far, as by grinding the tissue with silica. In section of the cervical sympathetic, the property of synthesising acetylcholine by the distal part of the nerve and the superior cervical ganglion was lost in about two days. This was also accompanied by a drop in the acetylcholine content of the tissue and an impairment of synaptic transmission in the ganglion. Feldberg, therefore, concluded that acetylcholine synthesis in sympathetic ganglia is the function of the preganglionic endings, and is a necessary prelude for normal sustained synaptic transmission. Brown and Feldberg (1936), MacIntosh (1941) and Feldberg (1943) observed that acetylcholine disappeared from the superior cervical ganglion of the cat following section of the cervical sympathetic trunk. After degeneration of the preganglionic fibres, the superior cervical ganglion lost its property of synthesising acetylcholine. This property is, therefore, associated not with the ganglion cells, but with the preganglionic nerve endings in the ganglion. The time of the loss of this property coincides with the time of impairment or failure of transmission of nerve impulses across the ganglionic synapses.

The chemical theory, like the electrical one, has not received universal acceptance. Acetylcholine is now considered to be a probable, though not an indispensable, step in the process of transmission, and in support of this view it might be stated that it is liberated in a ganglion when preganglionic fibres to it are stimulated. For the slower types of transmission, e.g., at post-ganglionic terminals, the evidence is practically conclusive that acetylcholine is the mediator between the nerve endings and the effector cells. But there is diversity of opinion regarding the more rapid types of transmission as found at synapses between preganglionic fibres and ganglion cells, and at myoneural junctions in voluntary muscles, though Dale and his colleagues maintain that acetylcholine is the transmitter in this rapid type also. This view was criticised by Eccles (1934) who doubted whether there existed sufficient cholinesterase in the ganglion for the purpose of removing the chemical transmitter from its site of action in the synapse within a short time. Marnay and Nachmansohn (1938) met this objection by showing that concentration of cholinesterase at the motor end-plates is many thousand times greater than in the muscle tissue, enabling the muscle to split the acetylcholine liberated by the nerve impulses during the refractory period. The latter observer also showed that the concentration of cholinesterase is several times greater in the superior cervical ganglion and in the grey matter of the central nervous system than in the preganglionic fibres and white matter. Probably both the chemical and electrical factors are concerned with transmission in the synapses and neuromuscular and neuroglandular junctions, and further work will bring the two views into harmony.

It will not be out of place to mention here the effect of epinephrine on synaptic transmission. Bülbring (1944) has shown that in the perfused

superior cervical ganglion the transmission of impulses on stimulation of the cervical sympathetic was modified by adrenaline. The contractions of the nictitating membrane due to stimulation of the preganglionic fibres were increased when small doses of adrenaline were added to the perfusing fluid, whereas these were decreased by adding larger doses. The increase was observed only with submaximal stimuli given at slow rates. The response to acetylcholine injected into the perfusion fluid was augmented by small amounts of adrenaline and depressed when larger amounts were present. On preganglionic stimulation for prolonged period the perfusion fluid collected from the vein from the ganglion, contained an adrenaline-like substance; this finding was confirmed by the chemical and biological methods of assay. It was suggested that the chromaffine cells which were found histologically in the superior cervical ganglia were a possible source of this adrenaline-like substance, and this substance might be collected in the venous effluent in the same concentration as that which was found to enhance the synaptic transmission when artificially injected. This substance also caused vaso-constriction in the ganglion. Bülbring's work had been confirmed by Torda and Wolff (1944) who working on the effect of adrenaline on the synthesis of acetylcholine had shown that the synthesis of acetylcholine by the brain tissue of the frog *in vitro* was increased from 40–150 per cent when adrenaline was present in the concentration of the order of 10^{-8} to 10^{-5} . This they attributed to the property of adrenaline of forming a reversible oxidation-reduction system.

In the early studies by Dale (1914), the action of acetylcholine has been shown separable into muscarine and nicotine-like categories. The muscarine-like effects are abolished by atropine which, however, has little effect on nicotine-like actions. A much larger amount of acetylcholine is required to produce a nicotine-like effect than to produce a muscarine-like effect. Armstrong (1943) suggested that there are possibly two types of cholinergic endings, one having a high content of cholinesterase and the other with little or no cholinesterase at all. In the former case the acetylcholine gives a nicotine-like action and in the latter case a muscarine-like effect.

The importance of ions in the transmission of impulses cannot be lost sight of. Ionic changes are certainly concerned in this phenomenon. Kraus and Zondek stated that potassium utilisation is controlled by the parasympathetic and calcium utilisation by the sympathetic. Brown and Feldberg (1936) observed that in perfusing a ganglion with a solution having the proportion of calcium normal for Locke's solution, but containing an excess of potassium, there was a prolonged liberation of acetylcholine, and only a brief initial burst of impulses from the ganglion cells, which then became inexcitable to indirect stimulation. Prolonged perfusion with potassium-rich solutions eventually resulted in failure of the acetylcholine output also. The effect of acetylcholine upon the ganglion cells appears to be potentiated by potassium ions. Bronk (1939) has shown that if, during perfusion of a ganglion with acetylcholine, the concentration of potassium is increased, or that of calcium ions decreased, the frequency of impulses discharged by the acetylcholine-activated cell is augmented. It has been noticed by Harvey and MacIntosh (1940) that on perfusing the superior cervical ganglion of the cat with a calcium-free solution there is no release of acetylcholine from the preganglionic nerve endings on stimulation of the sympathetic trunk or following the injection of potassium salts. There is also abolition of synaptic transmission. This abolition cannot be due to a loss of power of conduction of the ganglion cells, for in the absence of calcium,

they exhibit continued spontaneous activity in the form of a repetitive discharge of impulses along the postganglionic axons. The preganglionic axons also appeared to be abnormally excitable. Harvey and MacIntosh opined that in the absence of calcium, potassium ions fail to produce their normal liberation of acetylcholine, which is regarded by them as the synaptic transmitter. They consider that calcium is necessary so that potassium can act to liberate acetylcholine from the nerve endings. It has also been shown by Brown and Harvey (1940) and Kuffler (1944) that calcium ions are essential for transmission at the neuromuscular junction. Similar results have been obtained from brain slices *in vitro* where the usual liberation of acetylcholine by potassium failed in the absence of calcium ions.

DIFFERENTIAL BLOCKING EFFECTS OF DRUGS AND SENSITISATION

The action of drugs having differential blocking effects on the responses to sympathetic nerve stimulation and to epinephrine and the question of sensitisation of autonomic responses were intensively studied since Dale's (1913) finding of the reversal effect of adrenaline after ergotoxine. Narayana (1945), however, did not find any modification in the response of the heart of frog to adrenaline after ergotamine (personal communication), nor did he find any modification in the response of the frog's blood vessels. Dixon and De (1927) showed that adrenaline injected into cats which had previously received big doses of isopropyl hydrocupreine, produced a very prolonged action, some three or four times as long as in the normal animal. They suggested that isopropyl hydrocupreine paralyses or depresses the inhibitory fibres (vasodilators) and leaves the vaso-constrictors, so that adrenaline produced an enhanced action. Raymond-Hamet (1939) observed an inversion of the effect of epinephrine on the vessels of the kidney by corynanthine hydrochloride, while the reflex response to occlusion of the carotid arteries was left unaltered. Bacq (1936) and Clark and Raventós (1939) found that pyrogallol produced an increase in the duration of responses of the nictitating membrane to epinephrine.

Rosenblueth and Cannon (1939) observed an increase in the sensitivity of the superior cervical ganglion to the stimulating action of acetylcholine after denervation of the preganglionic fibres to the superior cervical ganglion in cats. After preganglionic denervation the sensitivity of the nictitating membrane to both adrenaline and acetylcholine was increased. Youmans *et al* (1939) showed that denervation of the intestine renders it more sensitive to the inhibitory action of adrenaline and also to several other sympathomimetic amines. It has been shown by Simeone and Maes (1939) that sympathetic denervation of the submaxillary gland of the cat by excision of the superior cervical ganglion increases its sensitivity to epinephrine, pilocarpine, and, less consistently, to acetylcholine. Phillips *et al* (1939) found an increase in the sensitivity of the blood vessels of a sympathectomised foot-pad of the cat with adrenaline as compared to the normal. Similar sensitivity of denervated vessels to epinephrine has been demonstrated by White and Smithwick (1940). The autonomic effectors of the iris, the heart of the cat, bronchioles and uterus have also been shown by various workers to be sensitised to their chemical transmitters by denervation.

The sensitisation to chemical agents of smooth muscles, glands, skeletal muscles and nerve cells, ganglionic and central, when partially or completely excluded from their normal nerve connections was stated by Cannon and Rosenblueth as the "Law of Denervation". This was specially marked with the natural stimulating substances, but was also found when other chemical substances were used. This sensitisation of the denervated effector

organs has been attributed to (i) an increased permeability of the cell membrane permitting an easier entry of the chemical stimuli, (ii) altered physical properties of the contractile cells, or (iii) diminution of the cholinesterase activity. But Marrazzi and Marrazzi (1941) have shown that the electrical conductivity of the denervated sensitised muscles is not consistently higher or lower than that of the normal ones, while no relationship or correlation was observed by Meng (1940) between enzyme activity and acetylcholine response in the denervated rectus muscle of toads.

THE AUTONOMIC NERVOUS SYSTEM, ITS CENTRES IN THE BRAIN STEM, AND SOMATIC RESPONSE

The independence of the autonomic nervous system, though disproved long ago, often subconsciously lingers in our mind even up to the present day. There is no denying that the word 'autonomic' is partly responsible for it. While the autonomic nervous system is sometimes restricted to the innervation of smooth muscles and glands from ganglia lying outside the central nervous system, it is now realised that these ganglia are incapable of independent activity when isolated from the central connections (Hare, 1941). Functionally they appear to constitute efferent relays in the preganglionic outflow from nuclei in the brain stem and spinal cord.

Karplus and Kreidl (1927 a) were the first to prove the existence of autonomic centres in the diencephalon. They showed a marked increase in blood pressure produced by stimulation of the hypothalamus; the effect did not depend on the integrity of the adrenal glands or the pituitary and the pressor effect was greatly diminished on section of the splanchnics. The work of Houssay and Mollinelli (1925) has shown that, around the ventral aspect of the third ventricle, there are masses of grey matter the stimulation of which produces secretion of adrenaline. The same effect has been observed on stimulation of the floor of the fourth ventricle near the middle line. These observations, along with those of Cannon and Rapport (1921), who also located a reflex centre for adrenal secretion near the front edge of the floor of the fourth ventricle, suggest the possibility of two regions in the brain stem, stimulation of which is associated with pressor effect and secretion of adrenaline. One of these is in the hypothalamus and the other in the medulla. It must be noted that the effects produced by bulbar stimulation may be due to stimulation of the direct pathway from the hypothalamus to the spinal cord, the bulbar centre being a relay centre in the projection pathway from the hypothalamus to the cord. Beattie, Brow and Long (1930) also indicated that there are centres in the hypothalamus for the control of adrenaline secretion. It is now believed that a number of nuclei are present in the hypothalamus, and possibly in the other parts of the upper brain stem, which govern to a great extent the functions of the autonomic system.

From the beginning of the twentieth century evidence has been accumulating, in every field, of the existence of a constant interrelationship between the visceral and somatic activities. Hiney (1940) has shown that stimulation of the hypothalamus produces somatic movements of the head, trunk and extremities, in addition to the visceral effects. This is found even after degeneration of all cortico-bulbar and cortico-spinal fibres.

CORTICAL CONTROL

There is ample evidence to show that the autonomic functions are subject to some degree of control from the cerebral cortex. The work of

Spiegel and his colleagues (1943) favours the acceptance of cortical control over the whole of the autonomic nervous system. These centres are more or less identical with the somatic centres. The control exerted by the cortex is not surely of such a vital importance to the vegetative system as to the somatic. The vegetative system can function automatically under certain conditions. Bard (1928) showed that a decorticated dog or cat, if disturbed or stimulated, would exhibit all signs of violent and exaggerated rage such as, struggling, biting, lashing of the tail, erection of the hair, a high pulse rate and a high blood pressure. These are reflex outbursts of sympathetic response due to activity of the posterior part of the hypothalamus with removal of the cortical control. Animals having the posterior part of hypothalamus destroyed did not show the spontaneous "sham rage". It is not unlikely that in man emotional instability and unreasoning fear or rage are due to release of the posterior hypothalamic mechanism from the normal cortical control.

Fulton and Ingraham (1929) proved that tracts of fibres arise from the frontal lobes and pass to the centres in the hypothalamus. Division of these cortico-hypothalamic tracts releases the hypothalamus from the control exerted by the frontal lobes and produces a state of chronic rage. Associated with rage there was evidence of diffuse discharge of the sympathetic nervous system. It is now believed that the autonomic functions are generally controlled from areas of cortex which are responsible for somatic activities of adjacent structures. Thus Karplus and Kreidl (1910 b) observed pupillary changes by faradic stimulation of a discrete point on the antero-medial surface of the frontal lobes. Dusser de Barenne and his colleagues (1941) have shown that stimulation of the frontal eye-field in the chimpanzee results in dilatation of the pupil and lacrymation. Penfield and Erickson (1942) have demonstrated that in man stimulation of the mastication-field of the lower end of the sensori-motor cortex produces salivation. Widespread sweating and vasodilatation which followed frontal lobotomy in man indicate some more general cerebral influence on the autonomic system (Freeman and Watts, 1942). Pupillary changes and lacrymation are produced on stimulation of the motor area for eye movement. Vasoconstriction or vasodilatation has been obtained from stimulation of certain points on areas 4 and 6 (Brodman). Bailey and Sweet (1940) have observed inhibition of respiration, rise of blood pressure and reduction of tone of the gastric musculature on stimulation of the orbital surface in the frontal lobe in both cats and monkeys. In cases of hemiplegia in men due to injury of the pyramidal tract, the skin of the paralysed limb may be warmer than that on the normal side in the acute stage, but much colder later. Bilateral ablation of the frontal lobes in animals produces loss of control of the bladder, gastric hypermotility, pyloric spasm and the development of intussusception. In dogs anaesthetised with chloralose, stimulation of motor focal points on the sigmoid gyrus is accompanied by a fall of blood pressure and an increase in the heart rate by about 20 per cent. Respiratory movements are usually decreased in amplitude and increased in number and occasionally apnoea may occur during cortical stimulation. The depressor effect, though associated with muscular movement, is not dependent on it. An increase of renal volume always accompanies the fall of blood pressure following cortical stimulation. It is, therefore, suggested that vasodilatation of visceral organs is probably responsible for the depressor effect (Hsu, Hwang and Chu, 1942). Morison and Rioch (1937) found relatively sharp localisation of the cortical regions whose stimulation facilitates or inhibits reflex response of the nictitating membrane of the cat. The cortical control over the muscles of the gastro-intestinal tract and other smooth muscles has also

been adequately proved by the work of Hesser, Langworthy and Kolb (1941) who found that bilateral removal of the motor cortices resulted in an increased activity and responsiveness of the gastric muscle. A similar effect on the bladder had been observed. Gardner (1940) stated that the centres for the voluntary control of micturition in man was located bilaterally in the frontal lobes. One of his patients had continence of urine after removal of one frontal lobe, but had incontinence when the other lobe also was removed. The concept of the influence of the cerebral cortex is further strengthened by the autonomic manifestations in certain psychic conditions. Thus in grief there is discharge of the lacrymal gland, and worry and joy are accompanied by peripheral vasoconstriction and vasodilatation respectively.

Thus evidence of control exercised by the cerebral cortex over the autonomic activities is fairly full and conclusive; nevertheless some workers have doubted the accuracy of these conclusions. Crouch and Thompson (1939), using electrical stimulation of the different points in the motor and premotor cortical regions in cats, dogs and monkeys could not find any cortical points from which certain limited reactions could be elicited. They also could not elicit any separate foci for sympathetic and parasympathetic functions. Williams and Scott (1939) also found peripheral vasomotor responses and galvanic skin reflexes on both sides of the body to be equal in a patient with complete hemidecortication. The weight of evidence, however, from the facts mentioned above and from clinical observations of various other workers points to a localisation in the precentral cortex, more particularly in areas 4 and 6 (Brodmann).

HYPOTHALAMUS

Recently much attention has been paid to this region of the brain, and evidence has accumulated to show that it plays an important part in some of the vital reactions of the body. It is now generally agreed that in the hypothalamus and in the other parts of the upper brain stem there exists a number of nuclei which govern to a great extent the reactions of the autonomic nervous system. Already a large number of sympathetic phenomena have been shown to be more or less dependent on the proper functioning of these areas. The hypothalamic nuclei have been grouped into supra-optic, paraventricular, infundibular and mamillary nuclei. Beattie, Brow and Long (1930) have shown that there are tracts of fibres which connect the hypothalamus with the spinal sympathetic centres.

The supraoptic and paraventricular nuclei have been found to be the most vascular areas of the brain, and to have a capillary bed at least six times more extensive than that of the cortical grey matter. It might be presumed from this that these highly vascular areas surround neurones which are specially responsive to changes in the blood. Scrota (1939), by inserting thermocouples in different regions of the brain, has shown that the temperature in the hypothalamus is 0.5° to 1.0°C . higher than that in the cortex. There is a fall of temperature both in the hypothalamus and cortex during sleep, the fall being more marked in the hypothalamus. He also has shown that this fall in the temperature of hypothalamus is not due to variations in the rate of flow of the blood.

Karplus and Kreidl (1927 a) were the first workers to show that electrical stimulation of the hypothalamus produced excitation of the sympathetic nervous system. They obtained pupillary dilatation, sweating, rise of blood pressure and inhibition of intestinal movements. Fulton and

Ingraham (1929) showed that the function of the anterior or supraoptic region differed markedly from that of the posterior portion of the hypothalamus. According to them, lesions in the pre-chiasmatic hypothalamus produced definite increase in the "wildness" of the animal. With lesions posterior to this level; Beattie *et al* (1930), found that the animals which were wild before became very docile after the lesion. They also showed that ventricular extrasystoles were produced in the cat by chloroform anaesthesia. These extrasystoles under chloroform anaesthesia had been shown by Levy (1912-13, 1913-14, 1918-20) to be due to sympathetic stimulation. The heart was immune to this effect after removal of the sympathetic nerve to the heart and the suprarenals. Stimulation of the posterior hypothalamic region caused a rise in blood pressure accompanied by extrasystoles after a short period, whereas in transection of the brain, produced by a cut passing from the anterior edge of the superior corpora quadrigemina behind to the level of the mamillary bodies in front, the extra-systolic arrhythmia disappeared and could not be elicited again by administration of chloroform. Evidence for the presence of a parasympathetic centre in the hypothalamus was also given by Cushing (1932). He showed that injection of commercial pituitrin into the lateral ventricle of man produced within a very short time the characteristic effects of parasympathetic stimulation such as intense flushing of the skin and sweating, fall in metabolic rate and temperature, salivation, lacrymation, nausea, vomiting and contraction of the small intestine. Penfield (1929) also reported similar effects in a patient with tumour in the region of hypothalamic nuclei. Heslop (1938) also established beyond doubt that the anterior part of the hypothalamus is a parasympathetic and the posterior part a sympathetic centre. He further proved that stimulation of the anterior hypothalamic region produced a marked increase in gastric tone and motility; whereas stimulation of the posterior hypothalamic region produced not only a less marked converse effect, but also a transient relaxation of the pyloric end of the stomach. Beattie (1932) noted that faradic stimulation of the tuber region in cats produced increased peristalsis of the stomach, with a flow of watery secretion from the gastric mucosa. He has shown that stimulation of the anterior region of the hypothalamus gives a parasympathetic response and that of the posterior hypothalamus a sympathetic one, in so far as gastric motility is concerned. Beattie and Sheehan (1934) described the effect of faradic and mechanical stimulation of the hypothalamus on intragastric pressure in the fasting cat and showed that stimulation of the supra-optic or anterior hypothalamic region resulted in a slight rise in intragastric pressure and that of the tuber region produced a much more striking effect; the latter effect was accompanied by a fall in blood-pressure and by a subsequent increase in the peristaltic movements of the stomach; whereas stimulation of the posterior hypothalamus in the fasting cat gave a slight fall in intragastric pressure and complete abolition of all gastric movements. This was accompanied by a rise in the blood-pressure. Wang, Clark, Dey and Ranson (1940) showed that stimulation of the anterior part of the hypothalamus produced blanching with occasional inhibition of gastro-intestinal motility which was followed by a marked excitatory effect on the gastro-intestinal movement, but the responses did not appear to be a simple vagal effect. Sheehan (1942) concluded that stimulation of the hypothalamus usually causes inhibition of movement of the large bowel; this finding is suggestive of the presence of a sympathetic centre in this region. Hess (1939) also claimed that stimulation of the anterior hypothalamus produced contraction of the pupil, while stimulation of posterior and more lateral part resulted in dilatation. Wang and Ranson (1941) demonstrated an average increase of heart rate of 5 to 25 per cent

over the control following a 30-second stimulation of the hypothalamus. Stimulation of the pre-optic region of the cat, according to Wang and Ranson (1941), slowed the rate of the heart by 6 to 19 per cent. Wang and Harrison (1939) showed contraction of the bladder both through the sacral autonomic and the hypogastric nerves when the anterior part of the hypothalamus was stimulated. Benetato (1940) showed that the injection of acetylcholine into the anterior part of the hypothalamus produced a fall in blood pressure, which was abolished or even reversed by atropine. He thus demonstrated the presence of a parasympathetic centre in the anterior hypothalamus. Further evidence of the presence of a parasympathetic centre in the hypothalamus is found in the experiments by Benetuto and Monteanu (1941) who showed that the application of acetylcholine to the tuberal region produced not only a fall in blood pressure but also an increase in the uterus-contracting power of the blood and spinal fluid, which was abolished by atropine.

TEMPERATURE REGULATION

The importance of the hypothalamus in the regulation of body temperature is now unquestioned. Though Isenschmid and Schnitzler (1914) suggested that the hypothalamus was concerned in heat regulation, no proof was forthcoming till 1930, when Keller first clearly proved that the hypothalamus is essential for the regulation of the body temperature.

Keller and Hare (1932) stated that the chief central mechanism for the control of heat production was situated in the hypothalamus, and on extirpation of this region the heat loss mechanism which is located elsewhere, is released from co-ordinated control. Magnon, Harrison, Brobeck and Ranson (1938) showed that in the cat local heating of the anterior hypothalamic area with high frequency currents caused heat loss especially through vasodilatation, sweating and panting. This suggests that there are some nuclei in this region which act as thermoregulators, responding to a change in the temperature. The generalised panting which began thirty to sixty seconds after the application of the heating current was accompanied by sweating of the pads of the feet and some vaso-dilatation. As a result, the rectal temperature always dropped several degrees centigrade.

Since this time, evidence is accumulating that there are two distinct and separate centres in the diencephalon for reactions to heat and cold. These are co-ordinated reciprocally to form a single mechanism in an animal. Extensive lesions of the hypothalamus might destroy the power of regulation of temperature, whereas small lesions might only impair either of the two centres. Clark, Magaun and Ranson (1939) working on cats have shown that large central lesions in the region dorsal to the optic chiasma and ventral to the anterior commissure lead to loss of power to withstand high temperature. This is caused by serious impairment of heat dissipating reactions, such as polypnoea and sweating from pads of the feet which prevent overheating. They have also shown that lesions of the posterior part of the hypothalamus in cats tend to cause a subnormal body temperature. These experimental animals exhibit vasodilatation and fail to shiver with the drop of the temperature. It is inferred, therefore, that responses to falling temperature are controlled by the posterior or the sympathetic group of hypothalamic nuclei. Though the prevalent idea is that shivering is dependent on the motor impulses from the central nervous system, yet McDowall (1943) produced shivering in the skinned limb of a chloralosed cat with nervous connections from the central nervous system severed. The experimental work of Keller and Hare (1932) indicates that the main shivering centre is situated in the posterior hypothalamic region. Hemingway, Rasmussen,

Wikoff and Rasmussen (1940) working on dogs produced further evidence that the centre for heat loss is situated in the anterior hypothalamus. Hemingway and his co-workers placed small gold-foil electrodes either in the anterior or in the posterior hypothalamus of the dog via a subtemporal route. The electrodes were heated after three months when the wounds had healed. Heating the electrodes placed in the anterior hypothalamus produced vasodilatation of the ear and inhibition of shivering. There was no panting. Warming the electrode in the posterior region of the hypothalamus gave no vasodilatation but induced sleepiness. The presence of a sleep centre in the hypothalamus had been demonstrated by Hess (1932) by electrical stimulation of the diencephalon in cats with specially prepared electrodes. Hess and also Dixhit (1935) further showed that sleep was a parasympathetic phenomenon. Beaton and his collaborators (1941) working on monkeys also showed that heating the preoptic region of the brain, that is, the area of the forebrain lying between the anterior commissure and the optic chiasma, with a low-voltage high-frequency current, produced vasodilatation, sweating and polypnoea identical with the integrated response of the animal to an elevated environmental temperature. The results indicated that this area contained elements normally activated by a rising blood temperature and in turn activating the mechanism of heat loss. Bilateral injury to the rostral hypothalamic region in the monkey had been shown by Beaton *et al* to be associated with a post-operative rise in the temperature of the body which, when untreated, reached to a fatal level. This experimental rise in the temperature is due to paralysis of the central mechanism for heat loss combined with heightened activity of the intact central mechanism for heat conservation. Guerra and Brobeck (1944) also working on monkeys had shown that immediately after the production of lesions in the anterior and anterolateral hypothalamic regions the sweating in the left hand decreased from 70—82 mgms of water per 10 minutes to 10—12 mgms in some and in others to 48—66 mgms. When the normal animals were kept in a hot dry room for one hour, the perspiration rate was doubled, but in animals with hypothalamic lesions no increase was observed, although there was an increase in their rectal temperature from 37° to 39°C.

Ranson and Magoun (1939) discussed the possibility of the existence of more peripheral thermo-regulatory mechanisms which could be active after high spinal sections. Work done showed that slow acclimatisation to temperature could develop in spinal cats. Clark (1940) suggested that these findings are probably due to metabolic adjustments of hormonal origin. He had shown that inspite of an intact thermo-regulatory centre, cats transected at the lower cervical region could not maintain a normal body temperature when there was an appreciable rapid drop in the temperature of the environment. In gradual fall of temperature, a fair degree of adjustment was possible, but when the cats were kept in a warmer room for a long time this power was lost.

From all these data it could reasonably be concluded that there are two distinct centres for regulation of heat and cold. The centre for reactions to heat is situated in the anterior part of the hypothalamus and that to cold in the caudal part of the lateral hypothalamus. Lesions located to the medial part of the hypothalamus in the regions of the infundibulum have no effect on either centre. Stoll (1943), however, has suggested the presence of a thermo-regulatory centre in the medial hypothalamic nuclei in cats. He has shown that destruction of this nucleus produces changes in the body temperature and alters the adaptation of the animal to external temperature. This should await confirmation.

On the clinical side, evidence is accumulating that tumours in the neighbourhood of the hypothalamus produce changes in the body temperature. Brodsky, Cohen and Gray (1944) cited a case of a meningioma in the frontal region above the sphenoid ridge in which the early manifestation was an elevated mouth temperature. It was surmised that this symptom was produced by pressure transmitted to the hypothalamus.

Since the mechanism of heat production is activated by the posterior hypothalamus, it stands to reason that it is governed by the adrenergically (sympathetic) innervated structures coupled with the somatically-controlled shivering reflex; on the other hand, the mechanism of heat loss is primarily governed by a cholinergic (parasympathetic) mechanism including sweating, vasodilatation, etc., coupled with the somatic reaction of panting. The function of maintaining body temperature is thus a highly integrated reaction involving both divisions of the autonomic nervous system and also important somatic reactions.

CONTROL OF BLOOD SUGAR

Mellanby (1919) showed that, in the cat, section at the level of the superior corpora quadrigemina is followed by prolonged hyperglycaemia. Bulatao and Cannon (1925) observed the same effect in decorticated animals. Emotional disturbances following experimental lesions of the pre-chiasmatic hypothalamus have been described by Fulton and Ingraham (1929) and they showed that there was evidence of diffuse discharge of the sympathetic nervous system. The findings of Houssay and Mollinelli (1925), Karplus and Kreidl (1927) and Beattie, Brow and Long (1930) also suggest the presence of a centre for the control of adrenaline secretion in the hypothalamus. Bettie *et al* have shown that experimental lesions of certain nuclei of the posterior part of the hypothalamus, which lie medial to the column of the fornix and the mamillo-thalamic tract are followed by descending degeneration in fibres passing into the thoracic and upper lumbar region. Descending hypothalamo-spinal tracts play an important part in the control of the bulbar and spinal sympathetic nuclei. De (1945 a) has observed that in cats the lowest plane of section of the hypothalamus which abolishes the hyperglycaemic effect of its posterior nuclei, passes through the anterior border of the superior corpora quadrigemina behind to the posterior edge of or through the mamillary bodies in front; that is, the colliculo-mamillary plane indicates the dorsal limit of the posterior nuclei of the hypothalamus.

Brobeck (1940) showed that, in cats, lesions in the hypothalamus predisposed to insulin shock and to severe hypoglycaemia, but that spinal cats in which the spinal cord had been completely transected in the lower cervical region recovered from a similar dose; this fact indicated that the thoracico-lumbar outflow was probably capable of functioning to some extent without any connection with the higher centres, because spinal animals in which the adrenals had been removed or denervated died of similar doses of insulin. Is the thoracico-lumbar outflow, without any connection with the higher centre, then capable of maintaining the blood sugar level? While discussing the question of temperature regulation, it has been mentioned that work done by Ranson and Magoun (1939) showed that slow acclimatisation to temperature could develop in spinal cats, and Clark (1940) has also shown that in spite of an intact thermo-regulatory centre, cats with section of the cord at the lower cervical region were unable to maintain a normal body temperature if the temperature of the environment dropped rapidly to an appreciable extent; but with a gradual fall, a fair degree of adjustment was possible. From these facts it is reasonable to infer that the spinal

sympathetic nuclei may be capable of maintaining the blood sugar level to some extent when their connection with the higher centre is severed.

De (1945 b) investigated the role of the general anaesthetics on the blood sugar level on the spinal sympathetic nuclei when these nuclei are separated from the higher centres. He could not find any significant part being played by these nuclei in the production of hyperglycaemia. It was found that, in spinal cats, the administration of small doses of urethane produced a significant fall in the blood-sugar level, possibly by depressing the metabolic activity.

The importance of the sympathetic nervous system in producing hyperglycaemic effect has now been proved beyond doubt. Minnitt (1932-33) showed that, during anaesthesia, the blood-sugar level rises irrespective of the method of anaesthesia. It has been also noted by De (1945 b) that the hyperglycaemia varies directly with the depth of anaesthesia, the deeper the anaesthesia the greater being the rise of blood-sugar and *vice versa*. His finding that the peripheral nervous mechanism took no part in the production of hyperglycaemia gave a very strong reason to believe that the cause of hyperglycaemia during general anaesthesia must be sought in some part of the higher centres. These facts, coupled with the observation of Bard (1928) that decorticated animals show reflex outbursts of sympathetic activity and sham rage, and that of Fulton and Ingraham (1929) that division of the cortico-hypothalamic tracts releases the hypothalamus and so induces a condition of chronic rage and produces diffuse discharge of the sympathetic nervous system, and various other factors led De (1945 b) to believe that all these general anaesthetics release the sympathetic hypothalamic centre from the cortical control. The poorer the cortical depression with the anaesthetic, the less the hyperglycaemia; and with the deepening of the anaesthesia, as more and more of the cortical control was withdrawn, the greater and greater was the rise of blood-sugar. Of course, in intact animals, during an operation under a general anaesthetic, a part of the hyperglycaemia is attributed to the stimulation of the nerve endings at the site of the operation, which send impulses to the centre for reflex secretion of adrenaline; a part is also played by an unknown factor which is possibly metabolic in nature (De and Datta, 1945).

From the foregoing statements it is clear that the hypothalamus plays a very important part in the body and controls a large number of body reactions. I must confess that the results of observations on this important subject, especially their association with the autonomic nervous system, though quite extensive, are still very incomplete and await further work.

My colleagues, I am afraid I have taxed your patience and forbearance to a high degree by this address, which has become fairly lengthy in spite of my efforts to cut it down. I thank you for your patient hearing.

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SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

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THE URGE FOR WHOLENESS

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It belongs to science to seek to explain the empirical data laboriously collected by it, though it is true that such explanations will themselves need a progressive reshaping and retouching in the light of fresh data as and when obtained. It is, indeed, difficult to refrain from seeking to formulate a comprehensive idea of a given field of scientific investigation. But such hypotheses do also facilitate and encourage further collection of data.

The present position of psychology is rather interesting. Even a psychologist like C.G. Jung, who, as it were, by temperament seeks to systematise, explain and harmonise, feels that we are not yet in a position to attempt a general theory of mind, human nature or consciousness. The reason is that the data so far collected, though vast and varied, yet needs abundant further supplementation to provide a sufficient base for a comprehensive view of human nature as a whole. While this opinion will be heartily endorsed by many other psychologists, yet the fact is that since the beginning of this century the science of psychology has witnessed the growth of a number of explanatory systems to deserve the name of schools of psychology. Many amongst us face this situation of conflicting schools and standpoints in psychology with serious disappointment and frustration. But we can not forget that the rise of these conflicting standpoints greatly facilitated and encouraged research yielding, on the whole, a good harvest of varied facts of human nature. These facts themselves and some of the theories offered to explain them, by virtue of their very partialities and onesidednesses, challenge and demand a general theory, wide and broad enough to cover all the varied facts of human nature. By virtue of the separate fields of investigation, which the various schools discovered for themselves within the same original subject-matter of psychology, and the striking new facts that those fields contributed, they do also powerfully suggest to us to look for other fields, which might yield new facts, crucial and determining, so far as human nature as a whole is concerned.

As we view, review and ponder over the diverse facts and theories of contemporary psychology and consider the exclusive claims of different schools for treating this or that aspect of mental life as fundamental, we feel irresistibly challenged to seek to determine the really basic trend or the most fundamental urge of human nature, the most essential characteristic of our subject-matter. We cannot but feel baffled by the exclusive claims of 'behaviour', 'sex', 'will for power', 'purpose', 'reflex action' or any other similar concept to satisfactorily explain human nature. Even a lay reader, if he reads representative books of different schools comparatively

and not exclusively, will have to ask himself, "Which of these many answers to apparently the same question, is really correct?"

Now we are going to consider another answer here, which the present writer has developed from a consideration of the general facts of evolution, yogic discipline and the form of consciousness reached by it, and the contemporary schools of psychology. According to this answer of ours a tendency to a progressive organisation, an urge for wholeness, is the really basic trend of not only human nature but of organic evolution as such.

If we consider the entire range of organic evolution from amoeba to man psychologically, we find a progressive growth of consciousness, seeking to rise equal to the needs of the environment. The tiny flicker of consciousness of the amoeba grows steadily in complexity and organisation always seeking to adjust itself to the growing environment. This is the character of the evolving wholeness of consciousness. But that this range of consciousness, which is marked by a sense of inadequacy in relation to the environment, is really a tendency to wholeness is confirmed by that highest reach of human experience, in which consciousness presents 'self-contained wholeness' as a fact. And by the general relation of sequence, such wholeness appears to be the goal of the entire evolution of consciousness. This, in brief, is our thesis.

'The trend for wholeness' throughout the ranks of the sub-human life consists of progressive perceptual adjustments to an ever more complex environment. In man, self-consciousness, making thought possible, widens the range of experience and a larger organising process, a whole-making tendency, assumes the form of what Stout aptly calls 'ideal construction', a construction in ideas. An ideally constructed world and self, encompassing indefinite expanse of space and time, thus becomes a possibility to man. But the more important thing, that happens to him, is that his self-consciousness affords to him a direct-awareness of his own psyche. In other words, he becomes conscious of the projection inveterately involved in his relations with the external world. This gives a radically new turn to the growth of his psyche. Instead of seeking adjustment with the external reality the 'wholeness trend' now recognises near at hand the divisions of the psyche itself as the essential sphere of its working. This already assumes the possibility of a psyche made good in its inner divisions and established in wholeness.

This hypothesis has arisen out of the author's occupation with practical yoga and mystic and religious psychology during the last few years. The prolonged, intensive, deep introspection consisting of an attempt at a constant awareness of the various impulses arising to the surface of consciousness and of the reflections and suggestions cast on it, affords a real insight into the past of the individual as also into the evolutionary goal to which his nature generally is tending. Introspection is, indeed, the primary method of psychology. The study of the mental processes of others, by experiment or otherwise, particularly where complex processes are concerned, presupposes a previous introspective study. However, introspection, to serve the purpose here intended, has to become a yet more perfect instrument. Wundt had indeed improved it by making it experimental. The Kulpe school extended its serviceability to the complex processes. But it must now learn to read the depths of mind from its surface phenomena and it is through such introspection, perfected through long practice, which an individual can wield with freedom from self-deceptions, that psychology can look forward to a fuller and deeper knowledge of human nature. The science of psychology will grow out of the collaboration of experts, wielding such introspection,

Now the principal fact, which such deep introspection reveals, is an ingrained tendency in human nature seeking to bend all its varied and vast material, conscious and unconscious, into the form of an evolving wholeness. This tendency becomes a direct experience at a certain stage of the growth of what Indian psychology calls the 'witness consciousness'. As a yogic student sets out on his path of self-knowledge and through self-knowledge, self-mastery, he seeks to become more and more conscious of the impulses, which sway him at different times. Given seriousness and patience, the student will soon discover the working of projection, the habit of assigning causality to other persons and things for effects, for which his own motivations have a responsibility. Having sufficiently appreciated the projection-habit, he gets ready to feel and grapple with the reality of his own psyche. A deep abiding motive to know his psyche, *as it is*, is the only pre-requisite. That given, he proceeds,—the help of an experienced teacher being a very valuable aid,—to explore his psyche. In doing so he develops his self-consciousness as a living force capable of observing the ever-changing mental activities. Now while he experiences, let us say a stomachache, he becomes conscious or rather self-conscious of it. In becoming self-conscious of it he achieves a relative separation or detachment from it. To appreciate this difference one has to contemplate the two states, in the terms of Professor Stout's example given in his 'Manual of Psychology,—that of observing the waves and that of becoming conscious of doing so, when surprised by the question, 'what are you doing'? In watching the waves the percipient is identified with his activity of perceiving. When questioned 'what are you doing?' that activity becomes an object and he, as observer of it, is distinct from it. Now the yogic student through prolonged labours goes on discovering his identifications with his varied experiences and through self-consciousness achieving his distinctness from them all. When this activity has been carried on for a certain length of time he will become conscious of the sub-conscious identifications revealed indirectly at the plane of consciousness. This will give some depth to introspective activity and he will look for identifications revealing themselves in the dreams or indirectly in the waking condition. When the same activity has been carried on for a considerable length of time the self-consciousness of the yogic student will tend to develop a settled sense of inwardness and depth. With that fairly achieved he can sometimes find himself placed in a form and poise of consciousness, which when it first occurs, might surprise him. It is marked by a unique joyousness, balance, poise and wholeness. To start with, it is likely to be a short experience, but this consciousness is qualitatively different from the ordinary consciousness, which is marked by division, contrary pulls and which on the whole operates through an economic balance of the numerous stresses and strains exercising their force consciously and subconsciously. The new poise of consciousness, in a persevering yogic student, will tend to grow to longer durations and in course of time may become fairly normal. This really marks a distinct plane of consciousness, recalling to our mind the two preceding ones, the perceptual and the conceptual. With many forms of yoga the enjoyment of this state itself is the goal, but with the form of yoga evolved by Sri Aurobindo, which is practised at the Pondicherry Ashram, this consciousness is a means for effecting transformation in the personality. Sri Aurobindo calls this the 'Psychic Consciousness' and ascribes to it the capacity of raising the impulsive tendencies of the consciousness to the form of its own harmony and wholeness. Psychic consciousness is different from the ordinary mental consciousness; the former pertains to the psychic being, the central fact of human personality, whereas the latter to the mind, the form of consciousness evolved

in interaction with the environment. The Pondicherry Ashram with a few hundred persons devoted to the practice of yoga affords a vast material of yogic experience. This experience confirms certain general principles as also reveals many individual differences. The experience of the psychic consciousness itself admits of large individual variations. Some might get it soon, others not. But, on the whole, given the right approach it is not so rare a thing as we are likely to believe. It can also occur and perhaps does occur in the course of our ordinary life. But we do not much notice it. It is, however, not the same as a relatively poised state of mind, which we do get off and on more easily. The former is marked by a quality of depth and intensity, which the latter has not.

This fact of experience is, to the present writer, a fact of very great importance. It, however, proceeds from a sphere of consciousness and human nature not yet explored and tapped by any of the contemporary schools. This new sphere, marked by the quality of a harmonious and harmonising consciousness, is obviously different from the 'chaotic' unconscious. And the ordinary consciousness, which represents the ego's adjustment with external reality, moving dangerously between the *Superego* and the *Id* of Freud's terminology, also lacks the essential harmony and creative effectivity of the 'psychic consciousness' of Sri Aurobindo.

Now if what we have called the psychic consciousness is a fact, verifiable and ascertainable under certain given conditions, then its character, which grows out of and succeeds the average human consciousness, must be of invaluable help to the understanding of the anomalies of our nature. The 'whole', 'self-poised', 'harmonious and harmonising' psychic consciousness must throw a new light on the conceptual and moral consciousness of man. The implications of the 'psychic state' which is an incipient samadhi state are very great for a theory of mind. We have ordinarily so far looked at mind as revealed in the normal human adult. It is not long ago when we started looking at it as a product of animal evolution, from below upwards. Psychoanalysis gave us a new angle, that of looking from the depth to the surface. Indian psychology offers a new approach, that of looking from above downwards, in view of the future evolutionary goal as reached in pioneer-individuals. These approaches are all complementary and a psychology earnestly seeking the whole truth of human nature will recognise the entire realm of experience, the conscious, the sub-conscious and the super-conscious as its subject-matter. When we are concerned with the understanding of an intermediate stage of a process, we cannot hope to understand it completely in terms of the stage or stages antecedent to it. An idea of the end towards which the whole process is moving is the most important single factor in this connection. Indian Psychology discovers this end in yogic experience of a harmonised and integrated consciousness as such and is thus obviously in an advantageous position to interpret the antecedent stages. However, it is true that Western Psychology has taken immense pains for an empirical study of the average human personality while Indian Psychology sought to know it primarily with a view to carry it forward to its higher stages of growth. But there can be no doubt that the fact of the harmonised and integrated consciousness and its character is a fact of unique value for interpreting the mental processes of the average divided consciousness and for testing and verifying many of our hypotheses. It is a crucial instance of incalculable value. However, a proper use of it will become possible to psychology only when the need for determining the goal of the evolutionary process as a whole is recognised and when the fact and the character of that state become more definitely ascertained to the satisfaction of the science.

The present writer has laid a great deal of emphasis on the reality and the value of what he has called psychic consciousness. He has characterised it essentially by the quality of wholeness or harmony. It is a form of consciousness harmonious and harmonising. Its will is a whole spontaneous will and not a strained and struggling will, working under the pressure of opposing will-tendencies. Its emotional quality seems to be broadly one of joy, whatever the circumstances. This evidently constitutes a whole concrete form of consciousness and we have, therefore, pleaded that it marks a distinct level and plane of development comparable to those already recognised, the perceptual and the conceptual. However our chief evidence in support of the reality of the fact of psychic consciousness is yogic experience. Now many amongst us are likely to rule out yogic experience as rather mysterious and thus reject its value as scientific evidence. But when we say so what we really mean is that we do not find yogic students readily submitting to our cross-examination and laboratory testing and verification. Indeed we do not find yogic experience offered to us so easily. Yet there is good evidence in support of the fact of psychic consciousness, which challenges our attention. There is a vast yogic literature bearing a large testimony. But happily for the scientific psychologist there has been a distinct revival of interest in yoga in India in recent years and certain yoga ashramas conducted under the guidance of competent masters offer the opportunities of ascertaining the conditions and the quality or qualities of yogic experience. However so far as the present writer is concerned it is out of a desire to offer to his colleagues the very best experience that he has made as a psychologist that he chose to address you on this subject.

An appreciation of yogic experience and its conditions is today after our experience of psycho-analytical practice relatively easy. The standards and the tests of validity of psychoanalytical principles and facts are different from the ordinary laboratory methods of verification. The psycho-analyst has no use for needle pricks, artificial shocks and surprise-lights of the ordinary laboratory. He deals with life, which in its ordinary course of contacts with the world has come to some sort of crisis. The facts of psycho-analysis are discovered in a situation of relation between the analyst and analysand, where the analyst is a person previously psycho-analysed and well conscious of his own conflicts and fixations, so that he is capable of a dispassionate observation and interpretation of the patient's facts of subconscious life. Obviously it is the intimate knowledge of the human psyche gained by the analyst through his own analysis which becomes the basis for the interpretation of the working of the other person's psyche. And Jung is evidently right when he says that "Even the most experienced judge of human psychology cannot possibly know the psyche of another individual; and so he must depend upon good-will, i.e., the good rapport with the patient, who has to inform the analyst when something goes astray". Thus ultimately it depends upon the individual's own deep introspection and the science of psychology has, so far as the fundamental truths are concerned, to rely upon corroborative introspective reports of the experts. Yogic experience is pre-eminently an individual fact. But it admits of corroboration and that is the test of its validity. The occurrence of this experience, undoubtedly, demands more exacting conditions than any other psychological experience. But for that reason we cannot discard it. Corroboration and verification by others is a condition of scientific truth, which is obviously more determined by social considerations than regard for truth. To be able to verify the findings of Freud, for example, it is necessary to relatively develop the depth of his insight into the working of human

nature, besides satisfying the objective considerations of observation. Thus a true judgment possesses possibility of corroboration, but it may not have been already corroborated.

While there is no doubt that direct experience must constitute the best evidence of the fact of psychic consciousness, yet there are other kinds of evidence of an interesting kind which we should also consider here.

But before we consider these other lines of evidence supporting the fact of psychic consciousness we must even at this stage consider the relation and value of the fact to the main thesis of this paper. Our thesis is that an 'evolving wholeness', a tendency to a progressive perfection of organisation is the principal feature not only of human nature but of organic evolution as a whole. This progressive perfection of organisation of life is more easily noticeable in the sub-human species, from amoeba to the ape, in an increasing adaptation to and mastery of an ever more complex environment on the whole. In man, however, the situation becomes changed. Through his power of thought he rises to an immensely greater capacity of dealing with his environment. But through development of self-consciousness, which makes thinking possible, he becomes conscious of deep inner discords, whose harmonisation becomes the direction of evolution, as adjustment with and mastery of external reality is now found to be dependent upon seeing through the working of projection and achieving the best economic balance of forces operative within the personality. Now the yogic fact of psychic consciousness, experienced and enjoyed by special individuals everywhere to which the yogic, mystic and religious literature bears wide evidence and which is to-day equally well experienceable by pursuing an intensive inner discipline of life, comes closely in line with the fact of general human consciousness. The fact, no doubt, occurs under rather exacting conditions of life, but when once its character is definitely ascertained its indirect effects in general consciousness will become easier to determine. But the quality of the fact, so distinct and unique, representing as it does a form of consciousness in which the so-called fundamental polarities of the general human consciousness are made good, must irresistibly compel our attention. The fact by itself, coming as it does in the wake of the divided general human consciousness, obviously becomes the more powerful single consideration in support of the hypothesis that human nature as also organic evolution generally present a picture of a self-evolving wholeness. In other words, what is basic to human nature and towards which it is tending is a form and status of fully organised consciousness in which its present polarities are harmonised and reconciled. But this tendency to wholeness appears to be marked by the experimental procedure, so that within the framework of general progression it becomes possible for individual men or species in the sub-human level to show signs of fixation, regression or any other form of deviation from the normal behaviour.

We will soon have to consider this hypothesis in comparison with other ones in the field and determine its value. But immediately we will resume the consideration of further evidence in support of psychic consciousness to establish its validity as best as is possible at the moment.

Among other evidences of the fact of psychic consciousness, besides direct experience through an intensive inner discipline, is the vast literature of yoga and of mystic and religious life. This literature has been as yet very little worked out by psychologists and as the present writer had emphasised in his presidential address of the Psychology Section of the Indian Philosophical Congress in 1937 he would do the same now, namely that India offers a rich field of varied forms of religious and cultural life and their mutual

impacts and that a study of them is a unique opportunity for Indian psychologist. Such study besides contributing some original facts to general psychology will also make a contribution to the general life of the country in promoting mutual understanding. Now this literature widely bears out that a fulfilled consciousness is a reality beyond doubt. While to modern European life the fact of an aggressive struggling consciousness working by a strained activity is an intimate fact, to the traditional Indian mind a fulfilled spontaneously operative consciousness is a familiar phenomena. A proper characterisation of this consciousness is really our task. But as to the fact of such consciousness the writer must contend that there is a wide evidence.

Among modern western psychologists practically all the credit goes to Professor C. G. Jung for the perception that this vast religious and mystic literature contains invaluable psychological facts and for having conducted and organised studies of the same. The *Eranos Jahrbucher*, published regularly since 1933, contains beautiful studies by him and others on the subjects of meditation, contemplation, symbolism, growth of psychic life or the process of individuation etc. etc. The exact subjects to which the discussions of the first three volumes are devoted are : Yoga and Meditation in East and West, Symbolism and Spiritual Training in East and West, and Spiritual Training in East and West. The aim and the purpose of this serial publication is well indicated by a sentence from the preface of the first volume. The editor, referring to the subject of yoga and meditation in east and west discussed in the book, says, "It appears to me important that this field of experience which had so far been considered and treated by individuals or in the form of exercises in rather small groups, is now being made available to a larger circle".²

Jung's own studies of human personality constitute most daring adventures in the field of psychology. His methods are empirical. Word-association tests, which is his creation, constitute a new method in psychology for the study of personality-difficulties. Further he has collected dreams and interpreted them and studied folk-lore and mythologies and sought to determine the general trends of the human psyche. But these methods are rather later developments; to start with, he was a medical man interested in psychiatry.

Freud's psycho-analysis has, indeed, lent depth to modern psychology. But Jung's analytical psychology is rightly a deeper strand of psycho-analysis. Jung has not only had the courage and the vision to explore the realm of spiritual experience of the east and the west, he has also had a width and depth in his outlook, which have enabled him to perceive the structure of human personality in a unique way. He shares the feeling with many other psychologists that we do not yet possess sufficient data to be able to attempt a consistent theory of personality, yet he is amongst the modern psychologists the one most anxious to explore personality to its deepest depths and offer an explanation of the total phenomena of personality. Now the personality is to him not the psycho-physical unity as the Gestaltists consider it. Personality is primarily the unique organisation of experience. The study of personality, therefore, is the study of the psyche, which is "the totality of all psychological processes, both conscious as well as unconscious"³. The Psyche is a dynamic system and the totality of force activating its movements is the psychic energy or Libido. Thus Jung's Libido is different from Freud's, in the latter case it being essentially sexual in character. The importance of sex was exactly the matter over which Jung at one stage felt that he could not accept Freud. He recognises sex as a powerful factor in personality, he also recognises Adler's 'will to power' as

a force in personality, but he insists that 'the spiritual' appears in the psyche likewise as a drive, indeed as a true passion. It is no derivative of another drive but a principle *sui generis*, namely, the indispensable formative power in the world of drives"⁴. Another sentence is further illuminating. Says he, "The polymorphism of primitive instinctive nature and the way of formation of personality confront each other as a pair of opposites called nature and spirit. This pair of opposites is not merely the external expression but perhaps also the very basis of that tension which we call psychic energy"⁵. 'The spiritual' according to Jung is the tendency to synthesization, a unique whole organisation and expression. We shall soon hear more of it from himself.

The above quotation also presents another basic idea of Jungian psychology: the law of inevitable complementariness. Jung discovers that the dynamics of the human psyche involve a few fundamental pairs of opposites. These are the conscious and the unconscious, the ego and the shadow, and lastly the sex and the contra-sexual, which is anima in the case of man and the animus in the case of woman. The various members of these opposites are no deductions from any principle, they are discovered through an analytical investigation of normal and abnormal experience. The conscious and the unconscious are essentially related, according to Jung, by way of compensation or complementariness. Repression is an extreme form of the same relation and is no fundamental relation determining the two to each other as Freud would affirm. The ego is the organised selfhood of an individual, adjusted to carry out its reactions to the external world. Jung discovers that to the ego there is an opposite polarity of an alter-ego, an unconscious counterformation. Similarly a man has an unconscious feminine anima and a woman a masculine animus. It is neither possible nor necessary for us to consider the evidence, of normal and abnormal personality or of dreams or of mythology and folklore, establishing these polarities. What is particularly interesting to us is his discovery of a fact above these polarities, which constitutes the centre in the entire dynamics of personality. To this centre belongs the essential quality of totality and wholeness. To activate this centre and thus re-synthesize the entire material of personality is to realise the wholeness of personality. This unique centre, which is free from a counter-polarity, is ascertained by him through an elaborate dream investigation, reported originally in an Eranos volume. The study involved four hundred dreams of a normal person. Of these four hundred dreams those which he calls the Mandala dreams are really relevant to our purpose here. The Mandala symbolism is a common fact of Tantra yoga and Lamaism. It consists of a variety of forms of pictures, but it always "contains at the centre a figure of the highest religious significance". Now regarding the Mandala dreams he affirms, "Indeed they represent—unless I am wholly deceived—a psychic centre of the personality that is not identical with the 'I', which is the ego-personality. This inference seems to him reinforced otherwise too. For he affirms that "All the usual little remedies and medicaments of psychology fall somewhat short (to explain personality) just as they do with the man of genius or the creative human being. Derivation from ancestral heredity or from the milieu does not quite succeed; inventing fictions about childhood, which is so popular today, end—to put it mildly—in the inappropriate, the explanation from necessity—"he had no money, was ill", and so forth—remains caught in mere externalities"⁷.

The evidence from dreams of the existence of a centre of personality is indeed not very large. Jung, in fact, recognises that Mandala symbolism

is represented distinctly in a few cases. But he is inclined to accept Mandala as an archetype and affirms that in the rest of the cases it must yet "play the part of a concealed whole around which everything turns in the last analysis"⁸. "Every life is", he affirms, "at bottom the realisation of the whole"⁹. However there is another line of evidence which is highly corroborative. Says he, "As regards the comparative evidence from history, we are in a more fortunate position—at least as to the general aspects of the subject. First, we have at our disposal the Mandala symbolism of the three continents; secondly, the special time symbolism of the Mandala, as it developed, particularly in the west, under the influence of astrology"¹⁰. This evidence from history is a unique discovery of Jung and it is most interesting to see identical motives expressed in a variety of symbolism employed in religious life and even otherwise. These symbolisms are, according to Jung, the expression of a distinct archetypal trend of human consciousness, which is marked by wholeness, harmony and totality. The centre or the self of personality, expressed in the Mandala symbolism and in certain dreams and visions, is endowed with the power of creative transformation; it "acts like a magnet upon the disparate materials and processes of the unconscious and like a crystal grating, catches them one by one"¹¹.

The evidence adduced above on behalf of Jung is rather inadequate. But he believes himself to be 'in a position to offer detailed evidence for his opinions'. And he concludes thus: "If we survey the situation as a whole, we come to the inevitable conclusion—at least in my opinion—that a psychic element is present that expresses itself through the tetrad. This conclusion demands neither daring speculation nor extravagant phantasy. If I have called the centre the 'self', I did so after ripe reflection and a careful assessment of the data of experience as well as of history"¹². The tetrad refers to four fundamental functions of the psyche according to Jung. Jung affirms to have devoted twenty years to the subject and is, for himself, entirely convinced of the existence of a centre in personality, which when activated would give the quality of wholeness to personality.

Indeed, the investigations of Jung are most interesting. They offer such a valuable corroboration of the fact of psychic consciousness of yogic experience. His approach is different from that of yoga and yet the conclusion is the same. Evidently the evidence of this conclusion can have a secondary and a corroborative force, inferential as it is in character, to the direct evidence of yogic experience. But it is, no doubt, a very happy idea of Jung to investigate the dreams of normal men of superior mentality. Freud drew upon pathological data for his dream theory as for the rest of his psycho-analytical ideas. An investigation of the dreams of persons devoted to yoga should yield an interesting evidence, throwing further light on the deeper workings of personality.

While Jung's is the best evidence for our purpose in the whole field of psychology, there is yet some further evidence which has its own contributory value.

Freud's preoccupation was the neurotic person; and in exploring and investigating the structure of the pathological psyche he discovered certain basic truths of the life of the psyche, which have shown their wide applicability to human life and civilisation. In his researches Freud landed upon many highly original ideas and he will undoubtedly stand a pioneer in many fields of investigation. But when we consider his thought as a whole, we cannot escape the impression that his outlook was much limited by his preoccupation with the neurotic and the abnormal. Very naturally we should learn from him more of the conflicts and repressions of the human psyche

rather than positively of any tendency to wholeness, fullness and a total living. There are, however, a few sentences in his New Lectures, which are of interest. While talking of the inter-relations among the ego, the super-ego and the id, says he, "It can easily be imagined, too, that certain practices of mystics may succeed in upsetting the normal relation between the different regions of the mind, so that, for example, the perceptual system becomes able to grasp relations in the deeper layers of the ego and in the id which would otherwise be inaccessible to it. Whether such a procedure can put one in possession of the ultimate truths, from which all good will flow, may be safely doubted. All the same, we must admit, that the therapeutic efforts of psycho-analysis have chosen much the same method of approach. For their object is to strengthen the ego, to make it more independent of the super-ego, to widen its field of vision and so to extend its organisation that it can take over new portions of the id. Where id was, there shall ego be"¹³.

Freud does contemplate that certain mystic practices may afford a greater penetration into the id. However he is sure that that is what psycho-analytic treatment aims at. But a final resolution of the polarities of mind, even as a concrete possibility, was out of his conception. A normal average adjustment between the opposing forces was all that was intended. But do his polarities not suggest, even necessitate a possibility of their reconciliation? In fact that seems to be implied. Psycho-analysis, which has engaged itself so far in raising the subnormal to the normal, has evidently the responsibility to consider the question of helping the average normal to rise to higher degrees of inner adjustment and harmony. Freud devoted all his time to the study of repression. Sublimation came in only incidentally, as a subconscious process of growth. It is definitely a future responsibility of psycho-analysis to find out whether conscious sublimation or transformation is possible or not and, if possible, what are the conditions of its working. The writer has distinctly felt during the last few years of his occupation with yoga that whereas Freud had devoted himself to the study of repression, Sri Aurobindo's principal undertaking has been the development of the technique of transformation, as a conscious activity, which, however, the science of psychology has yet to appraise and assimilate.

It is hardly necessary to say here that Jung's perception of human personality is much profounder than Freud's. For Freud the strengthening of the ego is the objective. Jung finds ego one member of two correlatives and the growth of wholeness in personality would require a reconciliation of the ego and the alter-ego, the shadow as he calls it, through mutual interpenetration. Jung's idea of pairs of opposites and their reconciliation by the activation of the 'Centre' of personality is such a parallel idea to the conception of the '*Dwandwas*', the dualities of mental nature, and, of the '*Dwandwatita*'—beyond the *Dwandwas*—the spontaneous soul activity of Indian psychology.

Among modern psychologists McDougall has a place all his own. He is surely not a great pioneer and a discoverer of new truths as Freud, Jung or some others have been. But he has admirable talent for wide synthesizations. He clearly grasped that animal, normal, and abnormal psychologies should be pursued and investigated as sister branches dealing with a continuous subject-matter. His two 'outlines' on normal and abnormal psychology are very aptly treated as Part I and Part II. The evolutionary standpoint and its value for the understanding of mental phenomena is also appreciated by him more concretely than by any other. A study of the

growing consciousness in the animal is the approach emphasised by him for the understanding of the human consciousness. What is more striking is the fact that he is conscious that the evolutionary process moves forward and that it may realise new form or forms of consciousness. In his theory of Integration of Personality he also visualises the possibility of a complete harmonisation of personality under a master sentiment. But it is interesting that the evolutionally possible new form of consciousness or a completely harmonised personality does not much challenge his attention and he does not inquire as to the character of such consciousness or personality. Perhaps these were to him too distant possibilities. Evidently he did not appreciate the value of these possibilities for the light they could throw upon present-day psychological problems. He, therefore, in spite of his staunch purposivism fell back upon the way of mechanical causation of material nature and searched for the antecedents of structural dispositions of instinctive behaviour for the explanation of the complexities of the socio-ethical life of man rather than inquire into the nature of the general evolutionary purpose, which was progressively being realised through the moving tide of evolution. If he had called instincts the realised and stereotyped purposes of our nature he would not have been wrong. But it was necessary to recognise that they belonged to scheme of a wider evolutionary purpose, which may be demanding a constant re-adaptation from them. Instincts could not thus be entities of structural dispositions, but instruments of evolving life, which were relatively sufficient upto a stage, but in man they are greatly modified, and sometime in the future they may be really changed out of their nature. This conception was perfectly consistent with McDougall's appreciation of evolution and its character as a basic force determining the various forms of life and consciousness. His citation from Nunn in the 'Outline of Psychology' offered in fact to represent his own position, bears it out. The citation is: "It (the hormie theory) comes to view the history of life as striving towards individuality which is expressed most clearly and richly in man's conscious nature, and finds, therefore, in that goal toward which the whole creation moves the true interpretation of its earlier efforts"¹⁴. In the revised edition of the 'Outline', McDougall still widens out this basic outlook, already so broad, by contemplating a form of consciousness higher than the present human one as an evolutionary possibility.

But McDougall failed to work out his purposivism fully. Virtually the same is noticed in Jung too, who is equally emphatic about the teleological character of the conscious and subconscious working. Having once recognised the prospective or purposive trend for their explanations they readily fall into backward looking attitude to search for antecedent causes. The present writer feels inclined to ascribe it to the general habit of mechanical explanation engendered by natural science. Yogic psychology alone takes a thoroughly purposive standpoint. And it is evidently easier for it to do so, since it knows the next larger purpose, which mind and consciousness are evolutionally tending towards. For a consistent purposivist psychology all behaviour would consist of pursuits after purposes, realisation of purposes or delays in realisation or frustration of purposes or deviations from purposes or resistance in the realisation of purposes. If mind, consciousness and behaviour are essentially marked off from material nature by a prospective attitude or a purposive tendency, then surely a thorough-going purposive psychology is yet a matter for the future.

So far as the 'idea of wholeness' of our thesis is concerned, obviously we cannot fail to recall Gestalt psychology. Von Ehrenfels had vividly

shown how *gestalt-qualität* 'the quality of the form' is a distinct fact. After him a whole line of eminent researchers have shown, through suitable experimental devices, how this quality is virtually so important as to essentially determine a complete outlook in psychology. The psycho-physical behaviour of the animal as of man is, according to this outlook, always a movement to close a gap or overcome a tension and achieve a state of balance, poise or wholeness. In the perception of an interrupted circle we have a tendency to overlook the interruptions. Learning or solving a problem is to overcome a tension. Now so far as Gestalt psychology demonstrates the tendency to wholeness as the basically determining movement in behaviour, it is all so fully corroborative to the thesis here considered. But it must, however, be pointed out that all the wholenesses considered by the Gestalt psychology are partial and incomplete wholenesses. These are wholenesses relative to the preceding situation. A whole wholeness would be a legitimate culmination of the incessant tendency to wholeness so clearly recognised by Gestalt psychology. However, regarding that state it has no curiosity. For yogic psychology that state itself is its original fact. Besides that, the Gestalt psychology refuses to learn from modern abnormal psychology that mind and the psyche possess a kind of independence over the body and persist in emphasising continually psycho-physical parallelisms as a sort of necessity.

Next it will be interesting to consider two Indian Psychologists, Bose and Mitra, who have formulated hypotheses which bear a close relation to the position here defended. Bose through a wide psycho-analytical experience has been led to diverge from Freud in certain respects and develop a position of his own. The original fact of his 'New Theory of Mental Life' is most interesting. We shall state it in his own words how he struck upon this fact. "In the course of my analysis", says Bose, "I found that the symptoms connected with a repressed element in the unconscious would not disappear even when it had been made conscious by analysis and the patient had accepted the truth of the interpretation. Apparently all the resistances had not been overcome. Under such circumstances a curious thing was seen to happen. The nature of the symptoms changed and the free-associations of the patient and his phantasies and dreams showed the presence of an unconscious element of the type opposite to that originally unearthed. The original repressed material had been apparently replaced by its opposite. The symptoms were therefore traceable to opposite groups of forces; this fact is well known to psycho-analysts, and is often represented in a dramatic manner in hysterics in whom manifestations affecting the right side of the body may be of an opposite nature to those involving the left side. As the analysis proceeded the opposite repressed tendency came into the conscious mind and the primary repressed element, which had been made conscious before, lost its significance or sank back into the unconscious level. Simultaneously with its disappearance from the conscious sphere or with loss of its significance, the free-associations were seen to be again influenced by it showing that the element was not destroyed but had only changed its state. When this was brought to consciousness again, its opposite, in its turn, disappeared from view. The see-saw mechanism, as I have termed it, would go on for some time with striking regularity, but with a gradually decreasing intensity of the opposite tendency and an increasing frequency of oscillation till a time came when both the elements would be conscious and acknowledged by the patient; it was only then that the symptoms disappeared"¹⁵. This see-saw phenomenon forms one of the basic facts of his theory. Bose has elaborately worked out his theory of opposite wish and has attempted to show that the theory explains mental

phenomena, as a whole, more satisfactorily than any other existing theory does. Evidently he carries the idea of polarities to its extreme. He is not content with a few pairs of opposites operative in the mind, but affirms that to every wish—and 'wish' simply indicates a desire—there is a contradictory opposite wish. "Subject-object polarity", however, "comprises within it all possible forms of opposition". But between this last polarity and the countless polarities of the individual wishes, there are surely distinct units of organisation, which give certain common characteristics to the wishes included in those organisations. These units of organisations do need to be identified and characterised. Jung seems to the writer to have done this with admirable success. The "logical character and the apparent completeness" of the theory is rightly apprehended by the author as the sources of doubt regarding it. Indeed see-saw mechanism has been demonstrated and some other facts too support it. The theory does also explain many kinds of behaviour more intelligibly. But yet the position that each wish must have its opposite wish does seem to involve a deductive operation from a more general principle of mental life. In fact such an attempt too has been made. Actions and reactions are equal and opposite is the principle, according to Bose, which holds good in biology and psychology as it does in physics. The organism acts and is acted upon by the environment and this relation is governed by the above principle. The author argues, "Since actions and reactions are simultaneously in operation and since they are opposite in nature it may be said that in all cases wishes having opposite qualities develop in pairs"¹⁶. Thus virtually the last foundation of the theory rests upon the assumption of the principle mentioned above and the theory possesses a sort of absoluteness because of the deductive necessity that it has in relation to that principle.

The position of Indian psychology in this connection appears to be very enlightening. Firstly, the nature of mind is such that we tend to fasten upon the appearances of things, the *Rupa*, *Rasa*, *Gandha*, the visual impression, the taste, the smell etc. Then, the conative aspect of mind involves a Raga-dweshya attitude, the like-dislike attitude and thus the mind in its reactions to things forms Raga or Dweshya in respect of their dominant impression at a time. Now a mind going by the appearances of things, forming likes and dislikes as it proceeds, is bound to form lots of desires of a contrary type. This hypothesis will be perhaps sufficient to explain equally well and therefore it will not be necessary to rigidly posit an opposite wish to every possible wish.

However it is interesting to observe the idea of '*Dwandwas*' of Indian psychology rediscovered and worked out in varied ways by Bose, Freud and Jung. But immediately in relation to our thesis what interests us more in Bose is the last sentence of the quotation given above. Says he, we will repeat, "The see-saw mechanism, as I have termed it, would go on for some time with striking regularity, but with a gradually decreasing intensity of the opposite tendencies and an increasing frequency of oscillation till a time came when both the elements would be conscious and acknowledged by the patient; it was only then that the symptoms disappeared". Now "when both the elements would be conscious and acknowledged by the patient; it was only then that the symptoms disappeared". What is that state? That is exactly the thing that interests us. The mind normally creates wishes of opposite quality as it proceeds; the environment and the organism by virtue of their interactions and the law of action and reaction must do so and yet a state is here contemplated in which the opposite tendencies are, as it were, transcended. Has this state any resemblance to

the *Dwandwatita* condition of Indian psychology? Later on in the exposition of his theory Bose propounds his "guiding principle" which governs the wishes. We have said above that the relation of the subject and the object presents the last polarity of mental life. Now Bose says that "All wishes are efforts at bringing about a psychological unification of the subject and the object". "The principle of unity is the only principle that guides our wishes". It obviously interests us deeply to ask what this principle of unity is and what is the state of consciousness implied where the opposition is unified. Here we feel that Bose is presenting a very profound truth of human nature, which was not observed by Freud. Jung, however, in his principle of the 'Centre', which lends wholeness to personality, had very concretely discovered the same thing now being suggested by Bose under his principle of unity.

Mitra's hypothesis, which we must next turn to, directly draws its inspiration from Indian psychology. In his "Suggestions for a New Theory of Emotion", which he also offers 'as a theory of mental life as a whole', he undertakes a laborious examination of the various theories regarding the nature of feeling and emotion. These theories he finds inadequate. His own hypothesis is that "mind is at first a vast store of potential energy in a state of perfectly stable equilibrium quite content and at harmony with itself. The external world enters this mind through the channels of the sense and makes impressions on it. The equilibrium is at once disturbed, and the harmony destroyed. Some of the potential energy is changed into kinetic form and activity is initiated in order to regain equilibrium and the disturbed harmony. I suggest, therefore, that the fundamental yearning of the Ego is for that harmony —"¹⁷ The state of perfectly stable equilibrium is mentioned as the state of 'Anandam' of Indian Psychology. "Various are the means", elaborates Mitra, "adopted by the mind to retain and realise even some sort of temporary harmony amidst the incessant attacks from different quarters. It is the main task of psychology to study these ways and means, surrogates and subterfuges, that are employed by the mind for regaining the paradise that has been lost"¹⁸. Reason is "a special modification of the uppermost layer of the mind, as it were, attempting to serve the purpose of preventing extreme dislocations of the harmonious arrangement within"¹⁹. Thus reason too is an expression of 'the primal yearning for harmony'. All emotions of anger, fear etc. are "different attempts made to recover or maintain the equilibrium that is lost or threatened."²⁰

The author claims that the theory is capable of accommodating within itself the various hypotheses of Freud, Jung, Adler and Bose. Further he claims that a meaning is (now) found for the phrase 'unbalanced mind' in connection with abnormality.

This theory has some striking correspondence with the thesis here presented. The concept of a state 'of perfectly stable equilibrium quite content and at harmony with itself' is the most obvious one. The fact of psychic consciousness, the principal basic fact of our thesis, too, is essentially a harmonious consciousness, tending to harmonise the varied materials of personality. But for Mitra the state is a pure assumption, for us it is a fact verifiable by yogic discipline and by some possessed naturally too. Further, for him it is an antecedent condition, the present state being a disturbance of that harmony and an attempt to return to the same. This point of the theory seems to accord ill with the essential forward movement of evolution and unless Mitra's supposition implies an inherent possibility and trend, discernible in the evolutionary process, just what our thesis affirms, there is surely here a serious difficulty for the theory.

He talks of birth as the fact that disturbs the original harmony. But human consciousness is a direct continuation of the animal consciousness. If any disturbance at all took place it must have been at the beginning of the evolution of consciousness itself. But the consciousness visibly emerges out of a primordial unconscious condition rather than from a conscious 'Anandam' state.

His perception of a poised and harmonious state as implied in our consciousness is very correct. He also suggests a view of mind which we will endorse. His statement that reason itself is "a special modification of the uppermost layer of the mind as it were attempting to serve the purpose of preventing extreme dislocations of the harmonious arrangements within" obviously implies a distinction between an outer consciousness and an inner consciousness, mind being the outer attempting practical adjustments with the environment. The inner consciousness is our psychic consciousness, the central consciousness marked by 'harmonious arrangements within'. Mind including reason is thus the superficial consciousness evolved out of needs of adjustment with the environment. However it cannot be forgotten that reason, while being essentially an instrument for coping with the external world more largely and effectively, is capable of paving the way and leading on to a plane of consciousness beyond itself, which is a culmination and fulfilment of the entire mental nature. When the 'harmonious arrangements within' are discovered, the individual also achieves a harmonious arrangement with the reality outside, because the individual having been freed from projections and identifications is able to see straight and clearly. Bose is right in rejecting Freud's principle of reality. Says he, "It is quite unnecessary to assume any separate reality principle. When the opposite wish is unhindered there develops the true grasp of the external world and when there is repression there is falsification of perception resulting in the development of an illusion or a hallucination"²¹.

We will endorse also the position that reason as well as all consciousness is an expression of 'the primal yearning for harmony'. But this is so rather differently for him and for us. His argument is that if his assumption of an original harmony is granted then he can show that the various mental activities, normal and abnormal, are attempts, well-directed or ill-directed, for the attainment of some sort of harmony in consciousness. For us it is a wide survey of the growing evolution from the animalcule to man that suggests a fundamental trend to an increasing wholeness. However the best evidence for his hypothesis is the experience of the emergence of a new form of consciousness, which presents 'wholeness' as a fact, the 'consciousness as such' as distinguished from the consciousness of subject-object duality of Bose and James Ward or that of so many different polarities of Freud and Jung.

Mitra's suggestion, though not very clearly stated, that his assumption of a state of perfectly stable equilibrium gives the proper meaning to the term 'unbalanced mind', is further an idea which we heartily welcome. The standard of normality or abnormality has been much discussed in recent psychology. And the best judgment that we possess on the subject is that the average is the normal, that the statistically common characteristics of behaviour, as determined by general social judgment, decide what is normal behaviour at a time in a place. But a science of psychology, seeking the essential nature of mental disorder as of mental health, is bound to feel uncomfortable in a situation like this. If mental health and disease are terms changing their connotation with social standards of behaviour and etiquette then surely it is difficult to have a science of the subject, A

practical science of mental hygiene will have to determine the character of ideal mental health and the conditions of its attainment and it is only with reference to such standard that we shall be able to determine mental disease. The fact is that such a standard of health being not in view and for practical purpose the general opinion regarding what is abnormal being of consequence, the science of psychology accepted the social judgment as evidence of a fact of truth. From the point of view of pure science this is obviously unsatisfactory.

However this difficult problem is not altogether insoluble and psychology need not in despair accept consensus of opinion as evidence of truth. Mitra's 'state of perfectly stable equilibrium' is evidently the true scientific norm, which is capable of giving proper meaning to abnormality. But besides this norm necessary to the science of psychology, we need to have a standard of practical working normality, which is determined by the general state of mental health or disease at a time. However the legal norm of abnormality is yet different. Bose's principle of unity has not yet been much elaborated, but it seems to suggest a scientific norm of mental health perfect and complete.

The thesis we have been defending above and the theory of mental nature we have lately presented must naturally justify themselves in relation to the facts of abnormal psychology. If the facts of abnormal psychology can be satisfactorily explained on our view then that evidently means a fresh support to the thesis. Now mind, as stated before, is the consciousness growing from the animalcule to man out of needs to cope with the environment. This consciousness basically involves the mechanism of projection and identification. That is to say, the organism in its relation with environment learns to cope with it through projections and identifications with the external objects. These identifications develop organisations under sentiments, which may be related to one another in different degrees of opposition or complementariness. The identifications can also be deep and intense or otherwise and have competition or a contributory relation amongst themselves. Now, when a person possesses identifications, attachments or fixations with objects, ideas and ideals, largely in conformity with the scale of life's values socially accepted or approved at a time, he will be a normal man in accordance with the standard of practical normality. But where this is not the case and the individual's two important identifications or two systems of identifications are seriously at variance with each other, a state of conflict will arise. Such conflict may be conscious or subconscious or one in which one of the tendencies, representing one identification or one system of identifications may be conscious and the other subconscious. Such a conflict may lead to repression and the numerous consequences of repression. If we accept with McDougall dissociation as a distinct cause of mental disorder, identifications being different and varied, it is possible for them to build up systems relatively independent, which under abnormal circumstances become dissociated.

The treatment of the mentally disordered will evidently consist in achieving release from the identifications, which are morbid, in the sense that they involve an adhesion to an object or person much in deviation from the socially accepted scale of values of the times or from the identifications which involve a keen conflict. Such release is made possible by the precedent fact of will for health and is obtained by the direct or indirect strengthening of the same; by the integration into this will for health the divergent and conflicting identifications, through being raised and recovered to consciousness. Freud and Jung, both consider that the fact

of raising the subconscious contents to consciousness itself achieves the cure. But as the repressions are made conscious to the patient in the dispassionate presence of the psycho-analyst, he more or less achieves a detached standpoint with regard to his repressed identifications. These identifications then losing their subconscious autonomous character receive a new orientation and become integrated to the major trend of the individual's will, which is normally the will for life and health. The cure is at the last instance really achieved by this reintegrated will rather than by the mere fact of a subconscious content made conscious.

The terms identification and projection are here used in an independent sense. The psycho-analysts amongst themselves too are not agreed as to the exact meaning of these terms. Projection means to us the inability to recognise the psychic structure of one's life and hence failure to understand the true causes of one's behaviour. Projection thus basically involves self-evasion and escapism. Projection is for us an abnormality involved in the form of the normal consciousness. The so-called morbid projections, as for example, in delusions of persecution, are simply extreme cases of the same. Introjected state is a reaction — the opposite extreme—to the normal condition of projection. Jung's extroversion and introversion have a close resemblance to projection and introjection. They too would be for us abnormal conditions or rather conditions, which are largely normal to the present state of evolution of man. In the right normal condition the individual will know himself directly by the process of a deep and intimate self-observation —the deep introspection as characterised before; and the dispassionateness, which such self-knowledge will give, will enable him to know the external reality dispassionately. Projection, an undue emphasis on the external, and introjection, an undue emphasis on the internal, will then both be corrected. This will afford release from identifications with outside objects and persons or inner ideas and ideals, whether in the acute forms of mental disorders or the general form of practical social normality. The individual will know himself as 'consciousness as such' and will react to the external world with the detachment necessary for dispassionate knowledge and action.

Thus our view is capable of reconciling and explaining the facts of normal and abnormal psychology as also those of religious and mystic psychology. A fuller presentation and working out of the theory into these three great departments of psychology is obviously outside the scope of this address. But perhaps as a general possibility the case has been sufficiently presented.

Among contemporary psychologists there are evidently a good many who have in some manner more or less sensed a form of consciousness higher than the thinking consciousness. Bose's principle of unity seems vaguely to suggest it. But he has otherwise affirmed 'consciousness as such'. Mitra is very explicit in asserting 'a state of perfectly stable equilibrium quite content and at harmony with itself'. Freud too is not closed to the possibility of a completely harmonised personality. 'Integration of personality' is a very concrete proposition with McDougall and he contemplates a master sentiment, which will be able to afford a complete synthesis to the personality as a whole. However Jung's work in this connection is definitely the most striking. By a strictly empirical investigation of personality involving primarily an interpretation of dreams of 'normal persons of superior mentality' and of the symbolism of mediaeval alchemy and religious life of the east and the west, he discovers a centre of personality, which is the one factor that unravels the mystery of human personality more than any other known explanation.

But, while the characteristics of the consciousness of the centre are so distinct and unique, Jung does not see in it a new plane and level of experience. The ego-consciousness, he clearly recognises, is marked by 'exclusion, selection and discrimination' and is a polarity in human personality opposed to a principle of the unconscious, which he calls the shadow or alter-ego. The consciousness of the centre or self is a consciousness of wholeness above all polarities. Evidently the latter is an experience of a level and plane different from that of the ego-consciousness, as the ego-consciousness of man organised by memory, imagination and thinking is different from the consciousness of the animal, determined by the immediate impulse. We can virtually distinguish three levels of experience. Impulse, desire and aspiration. Experience being primarily conative these three terms are well-suited to designate the levels of experience. Impulse is a conation, self-seeking and limited to the present moment. A 'here and now' is its necessary condition. Between impulses themselves there is hardly any co-ordination. Each impulse as it arises governs the organism. However, if two impulses happen to be aroused simultaneously they can mutually inhibit each other or reinforce each other, according as they happen to be contrary or mutually helpful. The impulse is the order of the day of animal life. Man with the emergence of ideation is able to re-live old experiences in memory and imagine new ones and thus desire, which is 'impulse working on the plane of imagination,' comes into being. Desire is a wider principle of conation, in the sense that it is not limited to here and now. It can cover past, present and future. That affords comparison and therefore a relative coordination of desires becomes possible. Out of such coordination sentiments and individual characters arise. However desire being essentially impulse and therefore self-seeking and egoistic, the organisations of character presented by men are ordinarily of the nature of compromises among rival impulses. A life of wholeness, in which the individual impulses become like members of an organism, all seeking the common good of the organism is not possible at the plane of desire. Conflict, compromise, suppression, repression, are normal and natural to this plane of life. And this is the general human plane of existence. The third plane of human experience is revealed by the fact of psychic consciousness achieved by any kind of religious, mystic or yogic discipline of life involving a whole-hearted turning of life's thought, feeling and will to the highest ideal of disinterested Truth or Divinity, capable of unifying life's countless desires. The result of such a course is the emergence of a new type of conation, which proceeds out of the united energies of the individual's life. This conation we would call aspiration, the psychic's own seeking, the willing, the whole willing of the psychic consciousness of Sri Aurobindo or of Jung's centre or self of personality.

Now while Jung clearly recognised the quality of whole-willing in relation to his centre or self, he did not see that it was qualitatively a new experience marking a distinct plane of consciousness. The result has been much contradiction and confusion in his thought. "Exclusiveness, selection and discrimination are the root and essence of all that claim the name of consciousness", and "a universal consciousness is a contradiction in terms". However, the yogis are to him 'past masters' in the art of attaining to wholeness of life. But the *samadhi* state, which they aim at seems to him "to be equivalent to an unconscious state". "In their case", says he, "the unconscious has devoured the ego-consciousness". "An accurate appreciation of the methods of the Pali-canon or of yoga-sutras" he is prepared to grant, "produces a remarkable extension of consciousness. But the contents lose in clearness and detail with increasing extension. In the end, consciousness becomes vast but dim, with an infinite multitude of objects merging into

indistinct totality—a state in which the subjective and objective are almost completely identical²².

Now while Jung recognises that the yogis attain to a wholeness of life, yet the highest state which they achieve is one of unconsciousness, which by his own characterisation is 'chaotic' in character. Surely we cannot ascribe to the unconscious the quality of wholeness, if its essential nature is chaotic. Jung argues, 'I am unable to separate an unconscious below from an unconscious above, since mind intelligence and purposiveness below as well as above'²³. And therefore what is not conscious—in the sense of ego-consciousness—is unconscious and a superconscious state—a consciousness higher in organisation than the general human—does not exist. But surely the intelligence and purposiveness of the chaotic unconscious is very different from that of the state of whole living possible to man. Jung ascribes to his unconscious a great variety of attributes. It is chaotic, it possesses the wholeness of the *yogi* and the contrary qualities usually ascribed to the absolute of the mystics²⁴. And in addition, he is so emphatic about his consciousness of the 'centre or self', which reconciles the last opposition of consciousness and unconsciousness. Evidently Jung's thought involves a recognition of a form and plane of consciousness, which is essentially characterised by the quality of wholeness. However owing to failure to recognise its full character he could not but class it with the unconscious. The superconscious is surely unconscious to us at the moment, but while the unconscious is the dynamic retention of our past, the superconscious is the inherent evolutionary possibility for the future.

If man is not the end state of evolution then surely the future possibilities of the growth of consciousness have in some sense a present reality. That is really our superconscious. The human form of consciousness is a superconscious condition with reference to the animal consciousness. And as in the higher animals it is possible to detect indications of the thinking mind, so in the human, at its highest reaches, indications can be detected, as they must be, of the future trend of evolution. This trend is clearly for a consciousness acting as a whole, possessing complete inner organisation. This trend is not a partially realised fact so far as the ego-consciousness is concerned, and so far as the unconsciousness is concerned we have in it just the raw material of that organisation. This trend cannot be accredited to the one or the other. It is, therefore, a possibility that is being progressively realised. Individuals, however, do exist and have existed throughout human history almost, who have confirmed the possibility by presenting it in their life as a realised fact. Jung got mixed up at a number of points for failure to recognise the superconscious as a distinct sphere from that of the unconscious. This is, however, the special field of research so far as Indian Psychology is concerned. Yoga has primarily aimed at realising the highest possibilities of human life. The past has mattered to it in a secondary way. But for western psychology the investigation of the past has been the whole business of psychology. But evidently the future of mankind is bound up with our knowledge of the superconscious, the laws of its working and the methods of its realisation. And in this connection the importance of Indian psychology is unique.

Jung's characterisation of *Samādhi* state as unconsciousness is inappropriate in more ways than one. The yogic discipline essentially proceeds by the practice of concentration. That the end of concentration should be complete dispersion of attention and unconsciousness is understandable. Further there are agreeing accounts of a large number of persons of the mystic class all the world over, who have described *Samādhi* or the ecstasie

condition as a state of intense delight. Moreover, persons who have reached that state and are capable of enjoying it periodically display in their ordinary life a composure and integration of life much higher than the average. All this would show that the *Samadhi* state is not an unconscious condition. However it must be granted to Jung that certain yogic tendencies, which were perhaps of the nature of aberration of yoga proper, have really aimed at an unconscious state and *Samadhi* has been to them no more than a deep slumber. Jung is also right in stating that yoga 'winds up with *Samadhi*'. This is, however, not the case with all systems of yoga. Sri Aurobindo's integral yoga, for example, cares for *Samadhi* as a means for raising the general level of consciousness, for transforming the divided consciousness into the form of 'whole living' normally. "Our object is", says Sri Aurobindo, "to make spiritual life and its experiences fully active and fully utilisable in the waking state and even in the normal use of functions"²⁵.

We have throughout emphasised that a wide survey of the evolutionary process and its important stages and facts should be the basis of a comprehensive psychological theory. A theory so widely based will alone be able to give a comprehensive explanation of the varied spheres of psychological life. We have already shown how our theory is capable of explaining and reconciling the facts of normal and abnormal psychology as also of religious and mystic life. Here we will do well to provide the facts of evolutionary background of our theory a little more fully.

Accepting McDougall's marks of behaviour for determining conscious action, we find amoeba our practical starting-point, though as the same author says "there is no obvious lower limit to the scale of purposiveness". The principle of continuity too is today empirically better founded than it ever was and that too would forbid us to assert abrupt beginnings in nature. The emergence of consciousness we notice in amoeba must, therefore, be rather supposed to have arisen out of a substratum of a sub-conscious, which we might call Primordial Unconscious. Now out of this tiny but widening flicker of conscious of amoeba, as the animal species advance a secondary unconscious is progressively formed. This field of the unconscious needs to be distinguished from that of the Primordial Unconscious for the reason that its contents have been in consciousness and are for that reason more easily available to consciousness again. This secondary unconscious advances in extent as the species of organic life evolve more complex forms of life. The Homo Sapiens, when it appears, has a substantially wider consciousness, but it has a still wider secondary Unconscious embodying the whole history of animal evolution. The experiments and experiences of the preceding animal species are in substance available to the Homo Sapiens. The wild life of the Homo Sapiens soon develops into the primitive life of man. Institutions begin slowly to grow and mould his life. But a long time does really separate the modern man from the beginnings of those institutions, when the civilising process started. The primitive man's experiences of attempts at civilised life constitute in itself a vast realm of the unconscious. This is the same as Jung's racial unconscious. The modern adult man's make-up is evidently very vast and complex. His range of conscious is wide. That yields to him a rich harvest of personal experience constituting a further field of the unconscious, which is the personal unconscious. It, however, stands upon the foundation of the racial unconscious containing all the archetypes of motivations, detected by Jung, finding expression in the general trends and symbolism of human mythology, dreams etc. Next to that comes the unconscious conserving the experiences of the animal ancestry going back

to the very beginnings of life. And then must come the general base of primordial unconscious out of which the first emergence of consciousness must have taken place.

The successive layers of the unconscious constitute the past, the history of the modern adult. It is a tremendous task to explore even in a small measure the contents that lie therein at its various strata. Freud and Jung have had the daring, patience and penetration to probe into the secrets of the unconscious, and by having tackled nature in its obscurest and most difficult regions have rendered a real yeoman's service to all science.

What are the general types of relation between the conscious and the unconscious is a question of very great importance. Repression is one general relation, involving a variety of modes of relation as represented by the different forms of defence reactions. Besides that, there is another kind of relation, the one obtaining in a process of growth between the present stage and the preceding stages. In the case of repression the unconscious is in opposition to the conscious, which holds it down by main force, in the latter case the unconscious is in co-operation with the conscious, undertaking to execute mechanically a host of movements and relieve the conscious for tackling situations needing attention. But in its co-operation there is an essential opposition. The unconscious has indeed contributed to growth, but it imposes a limitation upon the conscious inasmuch as the unconscious is not amenable to a conscious control. It is a mechanising force and tendency. The growth and the working of habit illustrates the action of the unconscious clearly. Habit is truly a principle of economy in life. The child progressively relegates to habits the newly acquired reactions so that it may go ahead with the mastery of fresh tasks. But it hardly needs much evidence to show that habit is also a limiting factor upon human character, felt most acutely where new situations demand new adjustments. The consciousness then feels restricted and cramped by the existing mechanisations of life's energy. The pedagogic principle advocated by Rousseau that no habits should be formed recognised at the least the limitation habit imposes upon conscious guidance and control of life.

The unconscious seems to be the sphere of mechanical working within the general purposive scheme of organic life. That incidentally shows the role that mechanical action might play in the general scheme of teleological behaviour.

The above is too general a characterisation of the process of evolution of consciousness and also of the relation between the conscious and the unconscious. Surely the evolution is an experimental process and the growth of consciousness has not taken place in a straight line. There has been much trial and error and the detailed facts of evolution bear out that there have been abortive attempts and regressions, fixations and a lot of other faulty movements. But on the whole, it is evident there has been a progress in the measure and efficiency of consciousness. Virtually we could say that evolution represents an urge for ever greater consciousness, but that is really equal to saying that it is moved by an urge for wholeness or whole living, as clearly expressed in the modern man, since that too involves the progressive conquest of the unconscious by the conscious. Thus a general survey of the evolutionary process does suggest and support the thesis we have presented.

Our thesis can yet claim a further merit. We had stated in the beginning of our exposition that the contemporary schools of psychology present a problem of the first order to any comprehensive psychological theory. Now it appears to us that our thesis is capable of showing a way of reconciliation

among these schools. This it achieves through an essential widening of the concept of the psyche. To the conscious and the subconscious it discovers and adds the superconscious. The superconscious to it is an implication of evolution itself. As to any stage of evolution, whatever it be, there is its present character and its past history, so has it a course of future growth too given to it as a possibility belonging to the nature of things. The last phase in reference to the present is the superconscious. Now the superconscious of man, as explored and investigated by Indian traditional psychology and present yogic experience, seems to reveal the true character of the evolutionary process as a whole. The superconscious state is fundamentally a consciousness completely organised and harmonised and clearly bears out to be a form and plane of consciousness distinct from that of the average human divided consciousness. This fact comes fittingly in the wake of human consciousness and therefore shows the end and goal toward which all conscious history seems to have tended. Thus we discover and become sure of the urge for wholeness as the most fundamental trend of evolution.

Now if the wide scope of the thesis and its general trend are clearly appreciated it will not be too difficult to see how it can reconcile the conflicting schools of contemporary psychology. While considering the general relation between consciousness and unconsciousness we have shown above how the unconscious is virtually the mechanising tendency of life. If that is true then we have reconciled the major conflict of our schools, viz., that of mechanism and teleology. To that we can add a fact of superconscious life. It has been observed that people through certain exercises of Hatha yoga involving an intensive discipline of attention and will are capable of stopping a physiological reflex like the heart-beat. As a phenomenon it is an interesting fact. But what is its value for a psychological theory? Does it not show that what is ordinarily mechanical and out of the control of consciousness can be recovered to conscious guidance through a special cultivation of will? Evidently as mechanical action it must already be a subconsciously purposive action. If our argument is valid then the behaviourists may well now know the proper form and sphere of mechanical action which they have always extended too widely. There can thus be an understanding between the two principal warring schools of psychology.

It is interesting here to refer to two attempts recently made to find a way of reconciliation among the contemporary schools. Woodworth really does not attempt a synthesis. He is content to discuss each school by itself. However he is not depressed by the conflicts and the so-called crisis of psychology and hopes that 'the-middle-of-the-rovers', the large body of independent psychologists, who are anxious to assimilate from each school, will develop synthetic psychology of the future. But Levine, the author of 'Current Psychologies' aims at a 'critical synthesis'. However in place of a critical synthesis one finds the conclusion that "the boundaries that delineate each school have not been so rigid as to prevent the infiltration of principles fundamental to each. There are no closed systems". Regarding the conflict of mechanism and teleology his statement is more interesting. Says he, "even Watson has brought in consciousness by the backdoor". Further says he, "The deeper we probe into the working of mechanism the less mechanical human behaviour appears. For a mechanism that performs prodigies of adaptation is to all intents and purposes an entelechy".

However this reconciliation of mechanism and teleology is obviously different from ours. For us mechanism is a valued principle of action. But it is the operation of the unconscious, recoverable to conscious purposive guidance.

The Gestalt school will evidently receive our hearty endorsement regarding its perception of the *gestalt qualitat* and tendency to close up gaps as fundamental principles of psycho-physical behaviour. However it needs to recognise, from modern abnormal psychology, the relative independence of the psyche over the body, so that its unvarying emphasis on psycho-physical parallelisms is modified. Freud, Jung and Adler can be heartily assimilated into the wide terms of our theory. The sex of Freud and mastery motive of Adler are terms arising out of and belonging to the human psyche upto the plane of thinking consciousness. As soon as we are able to recognise the superconscious plane, the plane of aspiration or whole-willing as different from that of egoistic desiring, we will see a consciousness above conflict. To that harmonised consciousness the impulsions of sex as any other and their repressions or diversions, are all relatively foreign. Therefore sex cannot be fundamental and final. Mastery motive too involves a situation of conflict and represents divided state of will. The state of whole-willing and its proved reality alone can show the correct perspective of these motivations. It is in fact in the ignorance of that fact of whole-willing that these as some other opinions continue to appear to us as final truths of human nature.

This is in broad indications the critical synthesis and reconciliation, which our theory is capable of offering on the much vexed question of the contemporary schools of psychology. Evidently it is impossible for us to go into greater details over this issue, even though it may mean a valuable substantiation of our thesis.

I am conscious of the length to which I have taxed the patience of my audience. But I would yet append a few words regarding the promise of Indian Psychology. We have already seen that the standpoint of Indian psychology is all its own. Yoga is indeed an art. It aims at the achievement of a state or a form of consciousness. But that involves a standpoint, which is, at the first instance, conscious of the goal, the evolutionally possible goal of human consciousness and then seeks to understand and interpret human consciousness in the light of that goal. The Gita presents a superb gem of psychological truth in its account of the desireless action possible when the *Dvandvas*, the dualities of experience, have been transcended and reconciled. This fact throws an illuminating light on the impulses and desires of the average life and without it we should be lost in the conflicts and anomalies of average mental life. The western psychology, even purposivist, turns to the past history for explaining the present. But in a system each part derives its meaning from the whole. In interpreting any stage of evolution we must attempt to consider possibly as large a part of the process as possible and not confine ourselves only to the course so far traversed without considering the full implications of the direction for the future it is tending to take.

This standpoint of Indian psychology and culture as a whole, gave it the seeking and interest for the investigation and discovery of the superconscious states. These states and the methods of their achievement are as important to man as his destiny. They involve the knowledge and the means of the development of personality, of the realisation of wholeness in life. Evidently a psychological investigation and appraisal of these states is of immense value. We have shown above how the fact of psychic consciousness is a supreme psychological fact helping us to clarify many of our difficulties. That evidently involves the problem of transformation or conscious sublimation. The question is, how is a normal individual to raise himself above conflict to the status of whole living? Indian literature of yoga as well

as modern yogic experience contain a great deal on the subject, which we have yet to explore, investigate and appraise for the benefit of general psychology.

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 3. Jung, *Psychological Types*, p. 588, 1933.
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SECTION OF ENGINEERING AND METALLURGY

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THE DEVELOPMENT OF ALLOY AND TOOL STEEL MANUFACTURE IN INDIA DURING WORLD WAR II

(Delivered on 4th January, 1946)

INTRODUCTION

In beginning this address, my first desire is to express my deep sense of the honour which you have done me in electing me President of the Engineering and Metallurgy Section. The honour is particularly gratifying to me, because, to a considerable extent I feel that it is conferred upon me as a representative of a great industry—a thing far greater than any personal achievement. It seemed to me therefore that a fitting address to this Section would be to present an account of the achievements of the steel industry in India and recount a story in which the joint efforts of metallurgists, engineers and technicians played a part.

Modern warfare because of its enormous and rapid consumption of materials acts as a stimulus to the development of production methods, and tests the ingenuity of scientists and engineers to the utmost. The 1st World War served to emphasize the growing importance of Indian steel industry as a factor in strategy. History has repeated itself and during the World War II, which has frequently been described as an alloy steel war, Indian steel industry has made great technical advances and have won warmer tributes. The rich experience of making alloy steels thus gained under the stress of war, will indeed be very valuable in the task of building up a great industrial future for India.

Before passing to the main subject of my address, I would like to pause for a moment to honour the memory of a most distinguished Indian metallurgist whose sudden death occurred over a year ago. Dr. Behram D. Saklatvala's name will be cherished by metallurgists for his work in the development of low-alloy high-tensile steels and vanadium bearing steels. He was the President of the Vanadium Corporation of America from 1919 to 1935. In 1924 he was awarded the coveted Grasselli Medal of the American Society of the Chemical Industry for his work in ferrous metals. I am sure I have the full support and sympathy of the Section in recording our sense of loss at the passing away of such an eminent personality from the field of metallurgy.

HISTORY OF THE DEVELOPMENT OF ALLOY STEELS

In the last few decades, ferrous metallurgy has created a new field in the manufacture and utilization of alloy steels. Sir Robert Hadfield, the

pioneer in this field, has said, "without iron we would revert to the impotence of the Dark Ages, and without alloy steels, our fate would be little better, for iron and the simpler forms of steels will not give us for, example, the hard-wearing toughness of manganese steel; the wonderful energy-saving properties of silicon steel, as used for electric motors, generators and transformers; the greatly reduced rusting qualities of chromium and other steels; the special magnetic properties of tungsten and cobalt steels for permanent magnets; and of manganese steel for application where non-magnetic material is required; also the nickel-iron alloy known as Permalloy with its extraordinary high permeability at low induction."

The great strides made in the metallurgy and development of alloy steels may be ascribed to the urgent need of the development of armaments and other ordnance materials during the periods immediately preceding the two world wars of the present generation. But for these developments, modern warfare could not be waged on a scale as vast as has been shown to be the case in World War II. In every phase of this development, it has been possible to trace a direct demand made by the engineer. This demand stimulated metallurgists all over the world to investigate the effect on carbon steel of all possible combinations of many alloying elements. An outstanding characteristic of the alloy steel situation is its great complexity.

About half a century ago, practically all steels in general use were of the plain carbon variety, which were graded according to their carbon contents. As the sizes and capacities of the machines were increased, the engineer made a demand beyond the capacity of the plain carbon steel. Again, in his quest for high speed operation, he made a demand for a combination of strength and toughness. To meet such critical demands, new steels were developed, which contained alloying elements, and which could be oil-hardened or air-hardened to produce enhanced physical properties. Again, the demands made by the engineer for better manufacturing characteristics, improved resistance to corrosion and high temperatures, have been met by the development of alloy steels that are free-machining, corrosion-resistant and heat-resistant.

Though the great possibilities of alloy steels were realized through the pioneer researches of Faraday and Hadfield, it was not until early in the present century that the cost of the alloying metals permitted the commercial manufacture of alloy steels and made it possible to exploit the increased efficiency resulting from their improved physicals. At this time, the Indian steel industry was still in its tender infancy. In the early years of its struggle against foreign competition, it had to be content with manufacturing ordinary plain carbon steels, chiefly for structural materials for home consumption and rails for the requirement of Indian Railways. Only about fifteen years ago, when the steel industry in India had established itself, did it begin to look around and put in serious efforts to try to get its rightful share of the special alloy steel market that was growing apace.

During the years immediately preceding the World War II, several types of low-alloy high-tensile structural steels were developed in England, America and Germany. These steels were developed to meet the specific requirements of a structural steel, which possessed a higher yield point and higher tensile strength than the ordinary plain carbon structural steel. Such steels had been obtained by the addition of small quantities of alloying elements like chromium, nickel, copper, manganese, phosphorus, silicon, molybdenum etc. These elements harden the steel, which being low in alloy content, can be conveniently made in the basic open hearth furnace,

"TISCROM" STEEL

The impetus to embark on the manufacture of a suitable alloy structural steel in India presented itself when the project for the construction of the new Howrah Bridge over the river Hooghly was being actively considered. The final specifications called for the use of high-tensile structural steel having a specified tensile strength of between 37 and 43 tons per square inch. The Tata Iron & Steel Co., Ltd., launched upon a comprehensive programme of research to produce a steel that would comply with the requirements of the specification in the building of this Bridge. In the initial stages of its development a number of difficulties were encountered, which were successfully countered. Certain difficulties were experienced in the rolling of sections in the mills, because the degree of spread of this steel under the rolls was found to be different from that of plain carbon steel. Roll pass designers had to step in and so modify the pass design that now it is possible to roll sections in this special alloy steel quality as well as in plain carbon quality on the same roll setting. Another difficulty which had to be countered was the removal of the tightly adhering scale from the surface of sections and so prevent it from being rolled in. "Tiscrom" steel, by the nature of the alloying elements present, produces a hard scale which is not as easily removed from the surface during rolling as is the case when rolling plain carbon steel. This was, however, effectively accomplished by introducing high pressure steam on every pass, which breaks off the scale and so helps in producing a clear section. The peculiar property of surface checking due to the presence of copper, had also to be faced. Before this steel could be accepted by the engineers responsible for the construction of the Bridge, a patent suit had to be contested by the Tata Iron & Steel Co. to prevent the use of imported high-tensile steel. A great deal of public opinion was aroused, and the suit was finally decided in favour of the Tata Iron & Steel Co. Thus, the production of the first alloy high-tensile structural steel came into being, and the new Howrah Bridge in Calcutta which is fabricated almost entirely out of "Tiscrom" steel will stand as a lasting monument of beauty and strength to the skill and ingenuity of the Indian metallurgists, steel makers, rollers and other technicians.

"TISCOR" STEEL

The earlier high tensile steels, as has already been indicated, were developed in order to employ higher fibre stresses in structural design. The range of working stresses here involved the use of steel compositions which set a limitation on the possibility of fabrication by welding. During the welding operation, the heat generated generally tends to produce a hard and brittle zone adjacent to the weld that would endanger the safety of the whole structure. Though safe welding of the "Tiscrom" type is possible, if welding is preceded by pre-heating or succeeded by post-heating, it is not practicable to submit large structures to such treatment. Therefore, the need arose for a structural steel, which, while having a high yield strength, would still lend itself to easy fabrication by welding in the usual way. The steel metallurgists went to work and produced "Tiscor" steel which satisfied these requirements. This is a quinary steel containing alloy additions of chromium, copper, silicon and phosphorus. "Tiscrom" steel described above is a quaternary steel with alloy additions of chromium, manganese and copper. In the development of "Tiscor" steel, the factor of weldability had to be held uppermost. Since carbon conveys the greatest degree of hardenability in steel, this element had to be maintained at a very low level and the higher yield strength was eventually obtained through a balanced

combination of the aforementioned alloying elements. The production of this steel was not attended without operational difficulties, which were of a similar nature to those encountered when developing "Tiscrom" steel, but these were all successfully overcome. "Tiscor" steel, although it possesses a tensile strength of nearly the same order as ordinary plain carbon structural steel, has a higher yield strength, by virtue of which, reduced thicknesses in sections can be safely employed. "Tiscor" is, therefore, an ideal structural material for use in the building of freight cars, trolley buses and various other tracting units where reduction in dead weight and an increase in pay load are desired. The applications of "Tiscor" in ship construction may include most structural members of hulls, such as outside plating, interior framing bulk heads, decks, tank tops; also water tight doors, hoppers coal bunkers, ash-wells, sky-lights, boiler breechings, air pre-heaters, stacks, and rudders etc. "Tiscor" Steel has also been found to be more corrosion resistant than ordinary plain carbon structural steel, which is a factor worthy of consideration in the construction of certain structural members. Thus we have to-day a high strength structural steel, developed and made in India, possessing high yield ratio with pronounced resistance to corrosion. "Tiscor" has come to stay.

BULLET-PROOF ARMOUR PLATES

"Tiscrom" and "Tiscor" steels were developed in the early thirties. From this time onwards up to the outbreak of the World War II, a small number of electric steel melting furnaces, which are pre-requisite for the manufacture of high quality alloy and tool steels were installed by the Tata Iron & Steel Co., a few other steel makers and by the ordnance factories in this country. These furnaces, however, were not put to their rightful use, for they were mainly employed for re-melting scrap and manufacturing plain carbon steels for sections and castings. A few of these steel makers, and the Tata Iron & Steel Co. in particular, did utilize these furnaces to make small quantities of certain alloy steels for their own works requirements, and it was this experience that stood them in good stead later when call was made upon them to supply various qualities and grades of special alloy and tool steels for their requirements during the period of the World War II.

In early 1940, the first call was made on the Tata Iron & Steel Co. at Jamshedpur, for the supply of armour plates for building armoured carriers for service in the Middle East. This call was made with a very strong scepticism in certain Government quarters that it would not be possible to manufacture armour plates in India. Such a defeatist idea was so strongly entrenched in the minds of a few that the impertinent suggestion was made to the effect that even suitable substitute plates in "Tiscrom" high-tensile quality or any other grade of steel would be acceptable to the Government, if the correct armour plate quality could not be produced. A request to the Government for any existing data on the manufacture of such ordnance material in the earlier stages did not meet with success. The Tata Iron & Steel Co., in order to vindicate not only its own established reputation, but in the larger and broader interests of national honour, was determined to go forward with its definite programme of research for the ultimate production of bullet-proof armour plate that could stand comparison with any that was produced in Great Britain or her dominions across the seas.

Having had no prior experience in the manufacture and production of such a class of ordnance steel, the work undertaken had to start practically from first principles without any help or guidance from sources elsewhere. To start with, the predominant factor which influenced the selection of the

composition and class of steel to be ultimately employed in the manufacture of these plates was the consideration of the facilities afforded by the existing plant and equipment available. Steels of oil-hardening or water-hardening types were ruled out as these would have entailed new installations of big and heavy quenching and straightening machines, with their attendant ancillary equipments. Efforts were, therefore, directed towards the production of an alloy steel of the air-hardening type. After several experiments on different compositions, such a steel was eventually produced on a laboratory scale from the 75-lb. high-frequency furnace at the New Research and Control Laboratories at Jamshedpur. These were rolled into thicknesses varying from 6 mm. to 14 mm. These plates were then subjected to ballistic tests. These tests refer to a standard ordnance specification and consist of firing three shots with .303 ordinary ammunition from a service rifle, normal impact, from a distance of 35 yards, with varying mean striking velocities, for plates up to 7 mm. in thickness. For plates 8 mm. thick and over, similar firing tests have to be complied with, but using .303 armour piercing ammunition from a distance of 35 yards. The conditions of acceptance under the firing test are very precise. Any plate penetrated, flaking at back or otherwise failing at the shooting test is rejected. Bulging after impact is permissible at the discretion of the Inspector. It will be seen that the ballistic tests are very severe, and necessarily so, and therefore, only the best plates will survive the test. Our initial efforts had been fully successful and had earned the remark from the Master General of Ordnance Branch, Simla,—"Excellent and up to Home specification".

The steel developed and described above was of the air-hardening type and contained the elements of nickel, chromium and molybdenum. The nickel content of this steel was somewhere between 4.0 to 4.50 per cent. The severe ballistic test requirements were met by a simple normalizing treatment followed by tempering at a low temperature. It is a matter for immense gratification that a research of such magnitude and novelty as regards the manufacture of such a critical ordnance material, was carried to fruition in the short space of about 3 months, and Indian metallurgists and other technicians may well be proud of their achievements.

This steel was then put into commercial production, and its manufacture was initially carried out from steel produced from the electric arc furnace. With the experience gained, this steel was subsequently also produced in the basic open hearth furnace. These plates were successfully rolled in the existing Plate Mill, the only one of its kind in India. Close metallurgical control was necessary at all the intermediate stages from steel-making onwards to rolling, annealing, machining, gas profile cutting, hardening and tempering and so on to the finished plate before it went up for assembling on to carriers. All the furnaces required for the necessary heat-treatment of these plates, such as annealing, normalizing and tempering were built locally, and soon a plant was got ready which could turn out about 800 to 1000 tons of annealed plates for fabrication per month.

Of all the difficulties experienced in the successful production of armour plates, the greatest was the extreme sensitivity of this steel to heating and cooling and the tendency for the occurrence of "flakes". This trouble was eventually cured by a rigorously controlled heating and cooling cycle at the different stages of production.

The early armoured carriers, popularly known as "Tatanagars" were designed for fabrication by riveting. A separate research had to be undertaken to develop a special bullet-proof steel for the manufacture of these rivets which had to be driven hot. Since it would not be possible to temper

the rivets after driving, it was considered that an air-hardening alloy steel, which could be hardened sufficiently by normalizing, at the same time possessing sufficient ductility without the necessity of a tempering treatment, would successfully meet the requirements. This did not present grave problems, as it was found possible to duplicate the armour-plate composition with the difference that the carbon and chromium contents in the steel (the two principal carbide forming elements and therefore conducive to hardness) were maintained at much lower levels. A successful bullet-proof steel for rivets was thus produced, which was subsequently used for the manufacture of bullet-proof rivets for the armoured carriers.

As the "Tatanagars" started rolling out of the assembly line in large numbers, it was soon realized that the shearing and riveting of the plates were causing a regular bottle-neck in production, and, therefore, gas profile cutting of plates and a riveted-cum-welded construction was suggested through the initiative of Tatas. This suggestion was put forward after tests were carried out on riveted and welded joints, whereby it was proved that the latter were much stronger than the former. A riveted joint, moreover, suffered from a grave disadvantage in combat service in that if an armour piercing bullet happened to strike on the head of a rivet, the occupants inside the carrier were liable to be seriously hurt by the splashing of the metal from the rivet shank. In a welded construction this danger did not exist as the metal joint was continuous and the weld was also bullet-proof.

ARC WELDING OF ARMOUR PLATES

There were certain major difficulties in the way of adopting the method of all-welded construction. In the first place, elaborate jigs would have been required to hold the plates firmly in position, and also be capable of being tilted to any position so that welding could always be carried out in the downward position. The East Indian Railway Works at Tatanagar who were entrusted with the fabrication of these carriers, felt that such jigs could not be designed and fabricated within a short period of time, and also that the cost of these jigs would be prohibitive. The lack of suitable welding equipment and competent welders at the time, were other factors which stood in the way of the adoption of the all-welded construction.

The difficulty of welding an air-hardening steel, especially under conditions of severe restraint, lies in the fact, that a hard brittle zone is produced adjacent to the weld, which is not able to adapt itself to the thermal stresses involved in welding. This difficulty was solved to a large extent by reducing the hardenability of the steel by lowering its carbon content and thereby decreasing the brittleness of the weld-hardened zone, but sufficient carbon being retained, so as not to impair its ballistic properties.

The next step was continued, with a set of experiments to determine a suitable chemical formula for a suitable flux-coated welding electrode, which would leave a deposit of such characteristics as would elastically deform under the thermal stresses produced during welding, and therefore, reduce the magnitude of these stresses to make the welded construction safe.

In order to expedite the manufacture of the armoured-carrier bodies, it was decided, therefore, to adopt a riveted-cum-welded method of fabrication. This raised new and interesting problems, but the Indian metallurgists again rose to the occasion. Gas cutting of the armour plates did not present too difficult a problem, as it was easily found that the tendency towards cracking at the edges of parts, cut from plates of heavy sections,

could be largely avoided by an initial annealing treatment. On the other hand, the welding of bullet-proof steel with marked air-hardening characteristics, however, raised problems affecting the composition of the plate, the welding rod and the welding technique.

Help had to be sought from other rolling mills for rolling and drawing different steel billets into various gauges of wires for ultimate use as welding rods. A long series of experiments had to be undertaken, and final ballistic tests had to be carried out on plates that had been finally heat-treated and then welded with the various types of electrodes. These welded plates had been subjected to the ballistic test in the same way as the straight armour plates (unwelded), in order to find out whether any flaw or defect made itself apparent under the terrific impact of the bullet. Eventually, a suitable flux-coated welding rod had been discovered and a correct welding technique had been evolved, wherewith a welded armour-plate was able to stand up to the severe ballistic tests required by the Ordnance Specification for unwelded plates.

This electrode wire steel was immediately put into production. The drawing of the wire had to be done elsewhere, as Tatas do not possess a wire-drawing mill. The drawn wire was then used by Tatas as a raw material for the manufacture of welding electrodes. Since foreign supplies were very scarce and highly irregular, this development of the special type of electrode was most opportune in hastening the production of the armoured carriers which were in high demand for combat service in the Middle East and the Far East.

The next step in the programme of research was the development of a suitable welding technique to produce satisfactory welds which would withstand the tendency towards cracking at the joint, at the same time possessing sufficient strength and toughness to stand up to the ballistic test. Such a technique was successfully accomplished at the end of a series of searching methods and tests. The firing test was carried out on a number of butt-welded armour plates, which were found to be entirely successful. In one test, the bullet in the centre of the welded joint had pierced the weld deposit, but so much of the energy of the bullet had been lost in this process, that it had left the bevelled edge of the plate underneath practically untouched. No sign of cracks could be observed near any of the bullet marks. The back of the plate also showed no trace of bulging at the positions where the bullets had struck.

Tatas, by then, had been producing their own mild steel electrodes for structural welding work, and, therefore, the actual production of these special type of flux-coated electrodes for armour plate did not present many difficulties. These welding rods were produced on behalf of the Government and were supplied to various engineering firms in different parts of India, who had been entrusted with the building of the armoured carriers.

At one stage, the Tata's armour plates were pronounced in England as unsuitable for welding, because, it was stated that they possessed a strong tendency towards cracking at the welded joints. This matter was pursued further by Tatas in their own interests, and, on further investigations, it was proved beyond doubt that the welded joints had cracked during the experiments in England because both the type of welding rod and the welding technique employed, had been incorrect and unsuitable for the welding of the air-hardening type of Tata's armour plate steel.

In this respect, India was well ahead of the progress made in welding technique, for armour plate welding was successfully accomplished in this

country much before it was attempted in England. One of the Government representatives, a welding expert who had been flown out to India, and who had been stationed at one of the railway workshops turning out armoured carriers, had expressed himself highly satisfied with the results obtained by welding. A number of welding rods from different manufacturers had been tried out by him on the welding of Tata armour plates, and he had expressed the opinion that the rods developed by Tatas had been found to be better than many foreign made rods.

SHORTAGE OF NICKEL AND EVOLUTION OF A NEW COMPOSITION ARMOUR PLATE

The chequered development of the manufacture of bullet-proof armour plates in India had to undergo another vicissitude in its short history when the battle of the desert was being fought to a standstill and shipments of nickel to this country were seriously threatened. Nickel was in short supply, and the necessity for the conservation of the existing stocks of this element was made imperative. A call went out for fresh research and this call again was not left unanswered for long. The metallurgist went to work and came back in a short while with a new composition of armour, possessing the same good ballistic properties and welding characteristics as his original armour plate composition, but having less than a third of the original nickel content in the steel. A number of experiments had to be undertaken to determine the perfect balance in the combination of the various elements, until finally, most of the nickel in the original composition had been replaced by copper and silicon, and the increase in chromium and manganese content being chiefly responsible for maintaining the original ballistic characteristics at a high level.

Several tests were made, both physical and ballistic on a few of the armour plates produced by two of the Dominions in the British Commonwealth to determine whether the armour plates produced in India suffered by comparison. Most assuredly, they did not. A few of the Dominion plates examined, required quenching in oil or water, followed by tempering at a suitable temperature to develop the requisite ballistic properties. Owing to the low alloy content of the steel, variations in heat treatment were necessitated in regard to variations in their sectional thicknesses. The extent of bulging after the firing test was also comparatively greater owing to the comparatively softer nature of the steel. In these plates, improved machinability had been attained at the expense of ballistic properties, and welding characteristics with regard to ballistic requirement were also found to be at a comparatively lower level.

By comparison, the Indian armour plate stands out with distinction.

By the nature of its chemical composition, the Indian armour plate possesses the advantage of a greater latitude in the range of heat-treatment, which remains constant for all sectional variations, thus allowing for a standard heat-treatment range for varying thicknesses. Further, the results of ballistic tests have shown that the depth of penetration of the armour-piercing bullet and the bulge at the back of the plate is much less in the Indian armour plate as compared to a few of the foreign plates examined. The following extract from an unsolicited testimonial, given by the Public Relations Directorate of the Eastern Army, and published by the Associated Press of India, speaks for itself :—

“An Indian Army observer with the Eighth Army reports that units possessing ‘Tatanagars’ swear by them.” “Many stories have been

told me", he writes, "of how 'Tatanagars' saved the lives of men under shell fire and bombing. Indian craftsmen may be proud of their 'Tatanagars'."

SCRAP-CARBON PROCESS FOR MANUFACTURE OF STEEL

Before the out-break of World War II, the ordnance factories in India used to make steel by melting a mixture of scrap and cold haematite pig iron. Soon after the commencement of hostilities, the supply of haematite iron, which used to be imported, was cut short, and the ordnance factories were placed in a serious dilemma as regards production of acid steel. A new method, almost a radical departure from the normal procedure, was worked out at Jamshedpur. This procedure, employed an all-scrap charge, carbon being included in the charge as petroleum coke. This process, having proved its worth on trials in Jamshedpur and found to be metallurgically sound, was offered to the ordnance factories for adoption. Technicians from Jamshedpur were also loaned to them for a short period to acquaint them with the technique of working this process, which eventually proved to be a complete success. By this novel process therefore, thousands of tons of important ordnance requirements, which could not otherwise have been satisfied, were successfully met.

MISCELLANEOUS ORDNANCE REQUIREMENTS

Although the greater proportion of the tonnage of alloy steels manufactured in India during the war was for armour plates, other ordnance requirements were not forgotten. Alloy steel shell bar, high sulphur free machining steels, forgings for armaments and alloy bar stock for the production of armour piercing projectiles were also successfully produced.

As the war progressed, demands were made from time to time for special steels, and these were successfully met. Alloy steel for the manufacture of parachute-harness, non-magnetic bullet-proof steel for amphibious craft, heavy armour plate for the proofing of high explosive shells, non-magnetic bullet-proof steel for helmets, heat-treated alloy steel bars for the repair of combat aircraft, etc., were all successfully manufactured and supplied as and when the need arose, but not without a considerable amount of research work and the surmounting of a number of practical difficulties.

SYNTHETIC PIG IRON

Synthetic pig iron was made from steel scrap and carbon. The synthesis was first carried out in the orthodox manner by melting scrap and an excess of coke in a basic electric arc furnace of the Heroult type, a method which was developed in the U. S. A. during World War I. The iron so made was cast into pigs. Being low in phosphorus and sulphur contents, this was an ideal substitute for good haematite pig iron for use in making acid steel as well as a recarbonizer for addition in the manufacture of high quality alloy and tool steels. Later, a process was developed for making this synthetic pig iron in the basic open-hearth furnace, which was much cheaper than, but still as good as the iron made in the electric arc furnace.

MINT DIE STEEL

While catering to the many pressing army and ordnance requirements, the manufacture of alloy and special steels for civilian needs was not neglected. During the war, when the shortage of small coins used as every day

currency was being acutely felt in this country, a general expansion of the production capacities of the existing mints was planned by the government. It was soon realised that a sufficient stock of imported die steel was not available to meet the increased demand. The call for help went out again. A careful study was made of the imported steel, and very soon, a steel was offered to meet the necessary requirement of the mints in this respect. The supply of mint die steel may be said to be the first attempt at the manufacture of quality tool steel in India. The early attempts did not meet with entire success as the dies did not reach the same standard of performance in service as those of foreign manufacture. As more experience was gathered, however, the processing of the steel was improved upon, and very satisfactory service performances have since been reported.

PERMANENT MAGNET STEELS

Research on permanent magnet steels was undertaken to meet the urgent demands of the Posts and Telegraphs Department of the Government of India, due to acute shortages of imported magnet steel bars. After much study and research, several types of magnet steels were successfully produced, including the chromium, tungsten and the high cobalt types. These steels are not easy to make and even more difficult to roll or forge. Eventually, however, the correct methods of processing were evolved to obtain the best results. The service performances of these steels have been reported to compare favourably with the imported steels.

HIGH-SILICON STEEL SHEETS FOR ELECTRICAL MACHINES

During the war, several enquiries had been made from time to time for the supply of high-silicon steel sheets for use in the manufacture of electrical motors, dynamos and transformers. The supply of these steels into India has so far been the monopoly of British firms. Since imports had dwindled down during the war, Indian industry was approached to fill in the gap. The manufacture of this steel did not present great difficulties. The rolling, however, and the subsequent processing of the sheets did require a considerable amount of work before finally a correct technique could be evolved to produce a sheet that would possess the necessary magnetic and electrical properties. The rolling and finishing temperatures on high-silicon sheets are critical. Similarly, the annealing cycle is even more important and should be closely controlled, so that a critical grain size and a definite orientation is obtained to give the best properties. These factors are not easy to control and the difficulties were enhanced because of the necessity of working with the existing plant and equipment which, in most cases were not quite adequate to handle the new work that had perforce been thrown in due to the emergency created by the war. Despite the difficulties, improvisations had to be effected and the job of work was eventually carried through successfully. The production of these high-silicon steel sheets in India has helped to bring about the prospect of establishing a stamping works in this country where these sheets would be used for stamping out laminations and other forms for use in the assembly of electric motors, dynamos and transformers.

MISCELLANEOUS TOOL STEELS

From mint die steel to tool steel is not a far cry. Enquiries came pouring in from the Government, Ordnance and Engineering firms in this country for tungsten die steels for hot work, high-carbon high-chromium

steels for extrusion dies, low-tungsten steels for hack-saw blades and oil-well bullets, medium-tungsten high-carbon steels for taps and cartridge drawing dies, silicon-chromium-tungsten steels for pneumatic tools, low-chromium high-carbon steels for razor blades, and other plain carbon steels for multifarious uses. These demands had been met with steel manufactured in the electric arc furnace and the high-frequency induction melting furnace and similarly processed.

CORROSION AND HEAT RESISTING STEELS

These steels are generally of the types that contain a fairly high proportion of chromium alone or one that contains a combination of chromium and nickel. Manufacture of these steels had never been attempted in India before. Since imported material was in short supply due to war conditions, ways and means had to be found to meet urgent demands. Eventually, these steels were successfully produced in the electric arc furnace and the high-frequency induction furnace. Stainless steel bars have been supplied for the manufacture of surgical instruments; sheets have been supplied for the manufacture of acid-resisting vessels for chemical plants. Heat-resisting steels for resistance to scaling at high temperatures, which contain fairly high percentages of chromium and nickel have also been manufactured and supplied for making steam valves and valves for internal combustion engines.

HIGH-SPEED TOOL STEELS

Of all alloy steels manufactured to-day, no other group of alloy steels has perhaps greater strategic value than the tungsten high-speed steels. Without these steels it will not be possible to turn out the innumerable guns and the countless rounds of ammunitions that are required to be expended in modern warfare. Nor will it be possible to turn out by thousands, in modern automatic machine tools, the countless machined parts required for armoured tanks and transport vehicles. Before the outbreak of the War, only one of the Ordnance Factories and the Tata Iron & Steel Company at Jamshedpur had installed small high-frequency furnaces which had long since replaced the time-honoured crucible for manufacturing high-speed steels. In the early days of the war, when the prospects of importing high-speed steels from abroad appeared to be very bleak, the Tata Iron & Steel Co. were approached by the Government to undertake the manufacture and supply of high-speed steels. A bigger furnace, 10-cwt. capacity was made available by the Government for installation at the works of Tisco at Jamshedpur for this purpose. Fortunately, this Company had sufficient experience of the manufacture of this grade of tool steel prior to the war, as high-speed steels for machine tools were then being produced in the small high frequency furnace at the New Research and Control Laboratories at Jamshedpur in small quantities, sufficient to meet its own plant requirements. India has been dependent on imports for the supply of ferro-tungsten, a principal ferro-alloy for use in the manufacture of high-speed steels. The Tata Iron & Steel Co. had, therefore, to face the problem of manufacturing ferro-tungsten locally, as existing stocks of the imported ferro-alloy were not sufficient for the continued production of this grade of steel. This problem was tackled with determination, and very soon sufficient quantities of high grade ferro-tungsten were being reduced from wolfram ore obtained from Jodhpur and elsewhere. Electric arc furnaces were designed and built locally, for none else were available by import from abroad, and soon a pilot plant was in operation for the production of the vital alloy, ferro-

tungsten. The production of high-speed steel was beset with difficulties, not because of lack of knowledge or experience, but, primarily, because of insufficient forging capacity. All efforts were made to increase the capacity in this direction and eventually it was possible to meet all the urgent demands of the Government for this grade of tool steel. The development of high-speed steel produced in India had to pass through great vicissitudes and adverse criticisms at the hands of indentors and users. Vested interests were largely at stake, and those outside India who had so far enjoyed a monopoly of export of this steel to this country began to fear a set back. The way forward was indeed very hard and difficult and we had to fight an uphill battle all the time. These steels were subjected to repeated practical tests to compare their performance with similar standard grades of imported high-speed steels, and the locally made steels in no case suffered by comparison. A case in point appears worthy of mention here. A responsible technical officer in charge of a section of an important Government department decided to put the locally made high-speed steel to a series of practical tests. Bars were selected by him at random from current production. Different types of cutting tools were shaped, and these were then finally heat treated and put to machining tests under standard conditions of feed, speed and depth of cut. The results of these tests amazed him, and he was only convinced of the fine performance of the tools when several repeat tests showed uniformly satisfactory behaviour. The production of high-speed steel still continues in this country, and one may well be proud of our achievement, for had it not been possible to supply this steel at a time when it was most needed in this country, much of the industrial war machine in India would have been at a stand-still and the vital war supplies from the "Arsenal of the East" would have been very seriously jeopardised. In almost every case, production manufacture had to be preceded by carefully planned laboratory-scale experiments in order to indicate to the consumer the correct processing to be adopted during subsequent manufacture of the finished article. To describe the difficulties encountered in the manufacture of the above steels would be beyond the scope of this short review. Suffice it to say that the difficulties were solved successfully and the demands were satisfied despite the fact that all the processing had to be carried out with equipment that had to be improvised, as the manufacture was carried out in plants which were not fully equipped to undertake the manufacture and production of these special types of steels. Nevertheless, it was a valuable experience and with adequate equipment it would be very helpful for the future development of the alloy and tool steel industry in this country.

FERRO-ALLOYS

No review of the development of the manufacture of alloy steels can be complete without a consideration of the production of the necessary ferro-alloys that are so essential for their manufacture. Ferro-manganese that is added to all steels has been manufactured in blast furnaces in India for a considerable time. When the recent claims that have been made for the advantages of adding this element to steel as manganese metal are substantiated, the production of electrolytic manganese will have to be seriously considered. Ferro-silicon and ferro-chrome which are also important ferro-alloys, have for some time now been in commercial production in Mysore. Ferro-tungsten has been manufactured in fairly large quantities in the pilot plant at the Tata Iron & Steel Co. in Jamshedpur. In the same pilot plant small quantities of ferro-titanium, ferro-columbium, ferro-boron, ferro-vanadium, ferro-chromium, ferro-phosphorus and silico-manganese have been prepared from indigenous ores.

Metals like aluminium and copper, which are also used as alloy additions to steel, are being manufactured in this country.

THE NEW CONTROL & RESEARCH LABORATORIES AT JAMSHEDPUR

The Tata Iron & Steel Co. having begun to feel the need of extended research in problems bearing directly on the production and processing of steel, completed the New Control & Research Laboratories at Jamshedpur in 1937, which are, perhaps one of the finest set of laboratories attached to any single steel producing unit in the world. These represent the first large-scale research laboratories constructed by private enterprise in this country to reap the full fruits of research. Time has more than justified their construction. These laboratories helped enormously to serve the best interests of this country during the World War II. But for the facilities afforded by these laboratories for research, no progress would have been possible in the successful development of manufacture and supply of alloy steels and a host of other steels of special strategic importance without which the industrial war effort of this great continent would have been nullified.

As the industrial greatness of a country is largely measured by its steel potential, the pioneer work carried out in these laboratories, in addition to being of immediate help to the United Nations in their struggle against world aggressors, may be taken as a sign to point the way to the future industrial development of India.

From the short review of the development of alloy steel manufacture in India that has been attempted and the part that India was thus enabled to play in meeting the urgent war time needs, one need not hesitate to acclaim the fine efforts put out by this country. India's strategic position and the gradual diminution of imports with increased shipping difficulties rendered it imperative for her, as never before, to develop her own war potential to the maximum. This was India's opportunity, of which she availed herself heartily and showed to the world what grim determination and practical resourcefulness could accomplish. Improvisation had been the order of the day so that supplies might reach the assembly lines in as short a time as possible. If we had waited for the proper equipment and all other ancillary facilities that could be so easily and so quickly acquired in normal times of peace, not even half of the total achievements as has already been indicated, in the field of industrial progress would have been made possible in the comparatively short space of the past five years. Let us, therefore, sing in praise of the ingenuity, resourcefulness and adaptability of the Indian scientists, metallurgists and technicians who have all shared together in bringing before the world the potentialities and the practical achievements of India in the field of the steel industry. The impetus of war had stirred enthusiasm in the minds of young men engaged in every class of industry and they were all imbued with one singleness of purpose. This purpose was to show to the world that Indians can stand on a par with any nation in the world in the way of development of indigenous resources provided equal opportunities and facilities are provided to them.

To illustrate the aptitude and the adaptability of the young Indian mind to learn and acquire real skill in the handling of new work, permit me to give you only one example. To operate the Wheel, Tyre & Axle Plant at Jamshedpur which was completed in 1942, efforts had been made to obtain technical services from Britain and America. But the pre-occupation of the industrial man-power and the risks and uncertainties created by the international situation rendered these efforts abortive. It was, therefore, to Australia that we turned for help, and it was Australia that stretched her

hands across the oceans and came to our rescue. The services of two of the senior technical officers of the Commonwealth Steel Company of Australia were loaned to the Tata Iron & Steel Co. at Jamshedpur to train up the crew for operating this new plant. This gesture of helpful assistance deserves praise. Unfortunately, however, these men arrived in this country before the new plant was quite ready for operation. When the plant did go into operation in January 1942, the iniquity of the treacherous Pearl Harbour attack by the Japanese, rendered the continent of Australia in immediate danger of aggression. When, however, Australia declared herself in a state of war with Japan, the two gentlemen from Australia, who had come all the way to this country to help us with their technical experience in operation, naturally expressed the desire to return to their own country to do their bit in the defence of their own homeland. Such a request could not be denied and they left these shores on the 2nd March 1942, barely three months after this new plant had been set in operation. But the young Indians who were put to work this plant, rose to the occasion and were able to carry on without any further help from outside. Remember, that these men had never before seen a wheel & tyre mill, but, within the space of a few months, they were able to master the intricacies of this type of rolling practice and they have since been turning out valuable rolling stock for use on the railways all over the country. These young men have certainly done a great job.

In the field of alloy-steel manufacture, great strides have been made, and the experience gained during the last few years should stand in good stead for the future development of this branch of the steel industry. The age-old myth that it is necessary to acquire half a century's experience before quality tool steels can be made, may be said to have been exploded for all time, when it is realized that it was possible to develop and produce armour plate in India on a commercial scale within the short period of about four months. Those who think along these lines are antiquated. Science has moved forward in the last twenty years. The pace of development has also accelerated, and facilities that did not exist twenty or fifty years ago, are now available for development. Our ways of thinking and working, therefore, have to be recast and made to follow rational as well as practical lines in keeping with modern trends and developments.

There are sufficient reasons to believe that the steel industry in India is to-day in a better position to meet the needs of this country in respect of alloy steels. These needs will grow with the further industrialization of this great continent, for the solution of our poverty lies in the rapid industrialization of this country, and the establishment of other major industries, like ship-building, automobile, aircraft, locomotives, machine tools, heavy chemicals and mining. Along with the rapid industrialization, the alloy steel industry, that has just been born, will, I hope, in the not too distant future, attain full manhood and take its place in the front rank of India's industrial array.

PROCEEDINGS

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PART III : ABSTRACTS

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SECTION OF MATHEMATICS

PRESIDENT : DR. RAM BEHARI, M. A., Ph.D., Sc.D., F.A.Sc. F.N.I.

Algebra

1. On dissimilar couples.

A. A. KRISHNASWAMI AYYANGAR, Mysore.

Let the elements of two similar finite ordered sets E, F be deranged into permutations P(E), Q(F) respectively. If a (1-1) correspondence is set up between the elements, say, I_P, I_Q occupying the place (I) in the two derangements we call $(I_P, I_Q), (J_P, J_Q)$ dissimilar couples, provided the relative orders (I_P, J_P) in E and (I_Q, J_Q) in F are inverse to each other. It is proposed to study in this paper the character of the number denoted by (P, Q) of pairs of dissimilar couples generated as aforesaid. Among the results proved we mention the following :

If a substitution $\begin{pmatrix} P \\ Q \end{pmatrix}$ is expressed as the product of cyclic substitutions $(P_1), (P_2), \dots, (P_r)$ then (P, Q) is congruent to $(P_1, P'_1) + (P_2, P'_2) + \dots + (P_r, P'_r) \pmod{2}$ where (P'_i) is a cyclic permutation of (P_i) . A remarkable similarity exists between the addition theorem of this function (P, Q) mod (2) and the multiplication of fractions.

The properties of dissimilar couples afford the simplest rigorous foundation for the theory of determinants.

2. On the period (mod p) of quadratic recurrence formulae.

R. C. BOSE, Calcutta.

In a letter to the author Dr. S. Chowla communicated the following result :—For Fibonacci's sequence 0, 1, 1, 2, 3, 5, 8, 13, ..., generated by the recurrence formula $\mu_{m+2} - \mu_{m+1} - \mu_m = 0$, $u_0 = 0, u_1 = 1$, we have for every prime p , $u_{m+p^2-1} \equiv u_m \pmod{p}$, except for the case $p=5$. In particular if $p \equiv 3 \pmod{10}$, then $u_{m+2p+2} \equiv u_m \pmod{p}$.

These results have been generalised in the present paper. Consider any recurrence formula (a and b being integers).

$$u_{m+2} + au_{m+1} + bu_m = 0, u_0 = 0, u_1 = 1$$

The least positive integer n, with the property that $u_{m+n} \equiv u_m \pmod{p}$, for all integral values of m, may be called the period (mod p), of the recurrence formula. The following theorems have been proved, regarding period (mod p), of the general quadratic recurrence formula given above (p being a fixed prime).

Th. (1). If $a^2 - 4b \equiv 0 \pmod{p}$, then $x^2 + ax + b \equiv (x-g)^2 \pmod{p}$. The period is pr where r is the index of g under p , i.e. r is the least positive integer for which $gr \equiv 1 \pmod{p}$. The period is a divisor of $p(p-1)$.

Th. (2). If $a^2 - 4b$ is a quadratic residue of p , but $a^2 - 4b \not\equiv 0 \pmod{p}$, then $x^2 + ax + b \equiv (x-\alpha)(x-\beta) \pmod{p}$. The period is $r_1 r_2 / h$, where r_1, r_2 are the indices of α and β under p , and $h = (r_1, r_2)$ is the H.C.F. of r_1 and r_2 . The period is a divisor of $(p-1)$.

The. (3). If $a^2 - 4b$ is a quadratic non-residue of p , then $x^2 + ax + b$ is irreducible (mod p). Let S be the index of b under p , and let t be the integral order (mod p), of the quadratic $x^2 + ax + b$, i.e. t is the least positive integer such that

$$x^t \equiv \text{an integer, } \pmod{p, x^2 + ax + b}$$

There are three cases to consider

Case I If both st and $(p^2-1)/st$ are even then the period is $2st$.

Case II If st is even and $(p^2-1)/st$ is odd, then the period is st .

Case III If st is odd and $(p^2-1)/st$ is even then the period is either st or $2st$.

The period is a divisor of $s(p+1)$.

It follows as a corollary from the above theorems, that unless $a^2-4b \equiv 0 \pmod{p}$, the period \pmod{p} , of any quadratic recurrence formula is a divisor of (p^2-1) . In particular for the recurrence formula generating Fibonacci's sequence, $a=-1, b=-1$. Hence from Th. (1), the period is 20 when $p=5$. If $p \equiv \pm 3 \pmod{10}$, then $a^2-4b=5$ is a quadratic non-residue of p , and from Th. 3, the period is a divisor of $2(p+1)$, since index of -1 is 2. If $p \equiv \pm 1 \pmod{10}$, then 5 is quadratic residue of p , and from Th. (2), the period is a divisor of $(p-1)$.

3. On the maximum value of $p(n, m)$.

H. GUPTA, Hoshiarpur, and F. C. AULUCK, Delhi.

$p(n, m)$ denotes the number of partitions of n into exactly m non-zero summands. It is shown that for large values of n the maximum value of $p(n, m)$ occurs when

$$m \sim \frac{\sqrt{6n}}{\pi} \log \frac{\sqrt{6n}}{\pi}.$$

This result holds even for small values of n . In fact for $15 \leq n \leq 200$ $p(n, m)$ is maximum when

$$m = \left\lceil \frac{\sqrt{6n}}{\pi} \log \frac{\sqrt{6n}}{\pi} + r \right\rceil$$

where $2 \leq r \leq 2.25$.

4. Peculiar remainders in repeated number dividend.

D. R. KAPREKAR, Devlali.

If $(a)_n$ represents a number 'a' of k digits repeated n times then the remainder when $(a)_n$ is divided by $(9)_k \times a$ is either equal to $a \times n$ or $\equiv a \times n \pmod{[(9)_k \times a]}$.

The method of putting down the value of the actual quotient for any value of n is also discussed.

5. Construction of difference sets from power cycles of the minimum function.

C. RADHAKRISHNA RAO, Calcutta.

If $f(x) = x^{t-1} + a_{t-1}x^{t-2} + \dots + a_0 = 0$ is the equation satisfied by a primitive element x of $\text{GF}(m^t)$, a_i 's belonging to $\text{GF}(m)$ where m is a prime or a prime power, then every power of x can be represented as a polynomial mod $[f(x)]$

$$x^a = \xi_{t-1}^{(a)} x^{t-1} + \dots + \xi_0^{(a)} x^0$$

The following theorems connected with ξ 's are proved.

Theorem 1. The $k = [(m^t-1)/(m-1)+1]$ distinct solutions d_1, d_2, \dots, d_k of $\xi_r^{(d+iv)} = 0$ for any $r=0, 1, 2, \dots, t$ are such that the differences $d_i - d_j$ ($i, j=1, 2, \dots, k; i \neq j$) reduced mod $v = (m^{t+1}-1)/(m-1)$ contain all integers less than v each $\lambda = (m^t-1) + (m-1)$ times.

Theorem 2. The $k = m^t-1$ distinct solutions d_1, d_2, \dots, d_k of $\xi_r^{(d+iv)} = a \neq 0$ for any $r=1, 2, \dots, t$ are such that the differences $d_i - d_j$ ($i, j=1, 2, \dots, k; i \neq j$) reduced mod $v = (m^t-1)$ contain all integers less than v and not divisible $\theta = (m^t-1)/(m-1)$, $\lambda = m^{t-1}$ times each and none of those divisible by θ .

6. Hypercubes of strength 'd'.

C. RADHAKRISHNA RAO, Calcutta.

Let there be t factors A_1, A_2, \dots, A_t each of which can assume m different values, those for the i -th factor being represented by $1, 2, \dots, m_i$. We define an ordered set $x_1 y_2 \dots x_t$ as a combination of t factors where x_i, y_i, \dots can assume values from 1 to m . There are m^t combinations of which a subset of m^k combinations may be called a (t, m, k) array. A (t, m, k) array is said to be of strength 'd' if all the combinations of any d factors out of t occur an equal number (m^{k-d}) of times.

It has been possible to construct such arrays when $m = p^n$ (p being a prime) for optimum values of t and d for given values of m, k, d and m, k, t respectively.

The optimum values come out from certain independent linear relations of the elements of the Galois field $GF(m^k)$ and the actual construction is done with the help of finite geometries. Such arrangements are termed as hypercubes of strength d as a generalisation of hyper latin and graecolatin cubes which are derivable from a (t, m, k) array of strength 2 only.

7. Characters of the symmetric group and the matrix solutions of equations.

M. ZIAUD DIN, Lahore.

It has been shown how the characters of the symmetric group can be used in obtaining the solution of equations in conjugate matrices.

A general method is indicated.

Geometry

8. Umbilical projection in four dimensions space S_4

SAHIB RAM MANDAN, Lahore.

This paper is an extension of the one published by the author in the *Proceedings of Indian Academy of Sciences*, Vol. IV No. 1 Section A, 1942, pp. 16-17 and another read at a meeting of the Punjab University Mathematical Society, Lahore on the 16th of March, 1942, the same submitted to Sir C.V. Raman for publication in the *Proceedings of the Indian Academy of Sciences* "to illustrate the use of Umbilical Projection" to establish a number of propositions pertaining to the Geometry of Spheres. For this purpose we investigate good many properties of a quadratic W in S_4 .

The paper is divided into three Sections.

First Section deals with "Harmonic Inversion w.r.t. a point and a prime in S_4 " and consequently with Inversion w.r.t. a Sphere. Properties of centres of similitude, and spheres of similitude and anti-similitude are discussed here in detail.

Second Section deals with "Conjugacy of lines and planes" leading to theorems on "Circles orthogonal to a sphere and 'Foci of a circle'".

In third Section many miscellaneous properties of W are discovered and corresponding theorems on spheres are described. Articles 1 and 2 of this section are of special interest, while articles 3 and 4 deal with "Radical sphere" of two spheres.

9. Some properties of rectilinear congruences obtained by tensor method.

RATAN SANKER MISHRA, Delhi.

Slotnic in his paper published in *Mathematische Zeitschrift* vol. 28 has given a method of applying tensor analysis to the study of Rectilinear Congruences. Representing a straight line of a Euclidean three-space as a special type of point—the dual point—he

has obtained certain results. The object of this paper is to obtain several properties of Principal Surfaces, Developable Surfaces and Distributive Ruled surfaces through a ray of Congruence with the help of these results.

10. A note on geodesic curvature.

RATAN SHANKER MISHRA, Delhi.

The object of this note is to obtain the geodesic curvature of the orthogonal trajectories of the generators of a ruled surface by a new method.

Theory of Functions

11. Some self-reciprocal functions.

R. P. AGARWAL, Lucknow.

In this paper I have investigated some new kernels and with the help of these have deduced certain functions which are self-reciprocal in the Hankel-transform.

12. On MacRobert function.

N. N. BOSE, Lucknow.

The object of this paper is to deduce the Laplace's transform of MacRobert Function and to investigate the properties of this function with the help of this.

13. On the derivatives of integral functions.

S. K. BOSE, Lucknow.

The object of this paper is to investigate some inequalities concerning integral functions of the complex variable z .

14. Parabolic-cylinder functions which are Hankel transforms of each other.

HARI SHANKER, Delhi.

In this paper it has been proved by the method of operational calculus that the functions

$$\phi(x) = e^{\frac{1}{2}x^2} x^{\nu+m-\frac{1}{2}} \sum_{r=0}^n n_{c_r} (-x)^r D_{-m-2\nu-r}(x)$$

and

$$\psi(x) = e^{\frac{1}{2}x^2} x^{\nu+n-\frac{1}{2}} \sum_{r=0}^m m_{c_r} (-x)^r D_{-n-2\nu-r}(x)$$

are Hankel Transforms of each other of order ' ν ' where ' n ' and ' m ' are positive integers or zero and $R(\nu - \frac{1}{2}) > 0$; and several well known instances of Hankel Transforms and self-reciprocal functions have been shown to be the special cases of this general result.

15. Two integrals involving Legendre functions

N. G. SHABDE, Nagpur.

Methods have been given by Titchmarsh, Cooke and Poole for the evaluation of

$$(i) \int_{-1}^1 (1+z)^{m+n} P_m(z) P_n(z) dz \text{ and } (ii) \int_{-1}^1 (1+z)^p P_n(z) dz$$

where m, n and p are positive integers and P_m and P_n are Legendre Polynomials of degrees m and n . No attempt has yet been made for the evaluation of these integrals for non-integer values of m, n , or p . In this paper these integrals are generalized for non-integer values of m, n and p . The main results obtained are

$$\int_{-1}^1 (1+z)^p P_n(z) dz = \frac{2^{p+1} \{\Gamma(p+1)\}^2}{\Gamma(p+n+2) \Gamma(p-n+1)}$$

and

$$\int_{-1}^1 (1+z)^{m+n} P_m(z) P_n(z) dz = \frac{2^{m+n+1} \{\Gamma(m+n+1)\}^4}{\{\Gamma(m+1) \Gamma(n+1)\}^2 \{\Gamma(2m+2n+2)\}}$$

These are true for integer as well as non-integer values of m, n and p and reduce to known results when m, n and p are positive integers.

16. On the singularities of a class of functions on the unit circle(II).

S. M. SHAH, Aligarh.

In this paper I prove the following theorem.
Theorem. Let $f(z)$ be a function regular in the whole plane including $z=\infty$ except probably on $|z|=1$ (where the singularities do not form an everywhere dense set). Let

$$\begin{aligned} f(z) &= \sum a_n z^n & |z| < 1 \\ &= \sum b_n / z^n & |z| > 1 \end{aligned}$$

and let $a_n = O(e n^\rho)$; $b_n = O(e n^\rho)$

where $0 < \rho < 1$. Then every isolated singularity on $|z|=1$ will be such that

$$|f(z)| \leq \exp \left\{ \frac{K}{|1-\tau|^{2/(1-\rho)}} \right\}$$

in the neighbourhood of the singularity.

17. An operational relation involving a generalized hypergeometric function and a theorem of operational calculus.

N. A. SHASTRI, Amraoti.

The operational representation of $x_k^{p-1} F_m \left[\begin{matrix} a_1, a_2, \dots, a_k \\ b_1, b_2, \dots, b_m \end{matrix} ; cx \right]$ is obtained for

general values of parameters involved in the function and a general theorem in operational calculus involving ${}_mF_m[a_1, a_2, \dots, a_m, cx]$ is obtained. Many of the operational relations so far investigated by other writers and some rules and theorems derived by Pol, Niessen and Humbert have been obtained as particular cases of the operational representation and the theorem given.

18. On the differentiability of functions.

P. D. SHUKLA, Lucknow.

Continuity of the function is the only necessary condition known so far for the finite existence of the differential coefficient of a function at any point. In this paper two more conditions have been established for the same purpose. These conditions are then utilised to find necessary conditions for the differentiability of the indefinite integral at a point at which the integrand has a discontinuity of the second kind. Suitable examples have been constructed to illustrate the various possibilities which can arise.

19. On Meijer-Whittaker transform.

N. D. TEWARI, Lucknow.

In the year 1942, Meijer gave a new transform, a generalisation of Laplace's transform. The object of this paper is to develop this transform on the lines of Laplace's transform.

20. On a new transform.

R. S. VARMA, Lucknow.

At the last Science Congress I gave a new transform, a generalisation of Laplace's transform. It has been possible to develop this transform further. The object of this paper is to give some more theorems on this generalised transform.

Applied Mathematics

21. Anharmonic pulsations of a homogeneous star : effect of γ , the ratio of specific heats.

P. L. BHATNAGAR, Delhi.

The paper deals with anharmonic pulsations of the homogeneous model for $\gamma=3/2, 13/9, 4/3$. The results for $\gamma=5/3$ have been given here for comparison from a previous paper. For a given 'outside-amplitude' the difference between the observed period of a star and theoretically calculated period on the basis of homogeneous model can be made to vanish by suitably decreasing the ratio of specific heats. But as the ratio of specific heats is decreased, the skewness deviates more and more from the observed value.

22. On dissipation in oscillations.

P. L. BHATNAGAR, Delhi.

In this paper I have discussed the non-adiabatic oscillations of a column of gas.

23. On the successive stages of formation in a cascade shower.

S. K. CHAKRABARTY, Bombay.

A solution of the equations of the Cascade theory of showers, taking into account also the collision loss is obtained which satisfies exactly the boundary conditions at the surface of the layer. The solution is expressed in a form which shows clearly the formation of the shower in its different successive stages. The contributions, to the energy spectra of the shower particles at any depth, of the different processes can now be calculated. Expressions have been given by means of which it is possible to calculate for all values of E_0 , the energy of the primary particle, the exact contributions, to the energy spectra of the shower particles at any depth t measured in characteristic unit of length, through (i) a process of collision loss only, (ii) a single radiation process, (iii) two successive radiation processes and (iv) one radiation followed by a pair-creation process. It is observed that the results obtained in a previous paper (Bhabha & Chakrabarty, *Proc. Roy. Soc. A*, 181, 267, 1943) are only the particular cases, valid for very small values of t , of the general results obtained in the present paper. It is also now possible to calculate the lower limit to the value of E_0 for which the particle ceases to multiply in passing through a given material.

24. A generalisation of binomial, Poisson and Lexian distributions.

NAZIR AHMAD CHAUDHARY, Aligarh.

In this paper I have considered the frequency distribution

$$f = (p_1 + q_1)^\alpha (p_2 + q_2)^\beta \dots (p_n + q_n)^\eta$$

where $\alpha, \beta, \dots, \eta$ are integers and $\alpha + \beta + \dots + \eta = n$. I have deduced from the distribution the Binomial, Lexian and Poisson distributions as particular cases.

25. The divergence difficulty in connection with the self-energy problem.

R. C. MAJUMDAR, Delhi.

It is well known that the relativistic theory of quantised fields gives rise to serious divergence difficulties, making it impossible to apply it to physical problems. In recent years attention has been drawn to the problem of self-energy of an electron which was strongly divergent in the original relativistic theory (one electron theory) proposed by Dirac. In the 'hole theory' which was later on developed by Dirac it was, however, found that the divergence of the self energy was only logarithmic. In the present work a general treatment for the self energy of the electron in motion has been developed. It is shown that the logarithmic divergence of the self energy in the 'hole theory' is due to symmetrisation in the behaviour of the electron with respect to emission and absorption of photons. A further generalisation of this theory has been shown to lead to the convergence of the self-energy. The theory is then compared with the recent quantum electrodynamics of Dirac where two new assumptions,—the λ limiting process and the negative energy quanta,—have been introduced in order to ensure the convergence of the quantised field theory. It is shown that the theory can be easily extended to the self-energy of Proton-neutron in meson field.

26. Five-dimensional space and some of its applications.

D. N. MOGHE, Poona.

Kaluza's extension of the general theory of relativity to five dimensions is found to have several advantages in solving problems of gravitation. In this paper an attempt is made to give a theory of the two body and allied problems. An approach is also made to a theoretical discussion of the double-star.

27. On dynamical stability.

K. NAGABHUSHANAM, Guntur.

In this note the inter-relations of the different types of dynamical stability defined by J. L. Synge are discussed.

28. On fluid motions superposable on an irrotational motion.

RAM BALLABH, Lucknow.

If q and Q are the velocity vectors of a rotational and an irrotational motion respectively the condition of superposability can be written as

$$(\nabla q) \times Q = \nabla \chi,$$

where χ is a function of x, y, z .

Solutions of the above have been obtained for given values of Q and χ . In particular if χ is a constant we get

$$\nabla \times q = \lambda Q$$

from which it is easily concluded that the surface $\lambda = \text{constant}$ contain the stream lines of the irrotational motion.

29. Finite strain in aeotropic elastic bodies-II.

B. R. SETH, Delhi.

The theory of Finite Strain in aeotropic elastic bodies developed in a previous paper (Proc. Ind. Sci. Congress, 1945) has been extended to the following cases :

(1) Torsion of a circular cylinder.

(2) Spherical and cylindrical shells under uniform normal tractions.

Assuming the aeotropy to be of the hexagonal type in the case of (1) an expression has been obtained for the torsional couple.

30. On a heterogeneous fluid motion.

H. S. TONDON, Lucknow.

Dr. Ram Ballabh in a previous paper (No. 28) has solved the equations

$$\rho(\dot{b} + bv\lambda^2 + av\lambda_2 - a\int \lambda_1 dz) = f(t) \sin [\int \lambda dz + g(t)]$$

and

$$\rho(a + av\lambda^2 - bv\lambda_2 + b\int \lambda_1 dz) = f(t) \cos [\int \lambda dz + g(t)]$$

in the case when $f(t)$ is zero. In the present paper I have proved that λ is given by

$$F\left(\frac{1}{\sqrt{2}}, \sqrt{1-\lambda^2}\right) = \frac{Z\sqrt{2}}{2} + K$$

where $F\left(\frac{1}{\sqrt{2}}, \sqrt{1-\lambda^2}\right)$ denotes the elliptic integral of the first kind in Jacobi's form

with $k = \frac{1}{\sqrt{2}}$ and k is the complete elliptic integral of the first kind, with assumptions.

$$\left. \begin{array}{l} a = \cos \theta \\ b = \sin \theta \end{array} \right\} \lambda_1 = 0, \theta = g(t) \text{ and } \mu \text{ a function of } t \text{ alone.}$$

31. Functional limits in two or more dimensions.

(MRS.) K. N. KAMALAMMA, Bangalore.

Let $f(xy)$ be defined at all points in a two dimensional interval. Except at an enumerable set of points the functional limits at a point in any angle will be equal to ordinary functional limits.

An identical proof of the theorem holds good for three or more dimensions.

32. Reciprocal differences in two variables.

P. N. DAS GUPTA, Patna.

A general formula for interpolation in two variables had been worked out by Lal and Das Gupta (*Bull. Cal. Math. Soc.*, July, 1941). For the purpose of interpolation, reciprocal differences were introduced by Thiele (*Integrationrechnung, Leipzig*, 1909). R-P differences in two variables were discussed by Singh and Das Gupta in Patna Bull Phil. Soc, Jan., 1944. In the present paper the author discusses some further work on the subject.

SECTION OF STATISTICS

PRESIDENT: PROF. K. B. MADHAVA, M.A., A.I.A. (Lond), F.N.I.

Theoretical Statistics

1. Calculus of difference sets.

A. A. KRISHNASWAMI AYYANGAR and A. K. SRINIVASAN, Mysore.

The first explicit reference to the construction of finite geometries by means of modular difference sets was made by one of the present writers (Krishnaswami Ayyangar) in an earlier session (1932) of the Science Congress held in Bangalore. Recently the introduction of the balanced incomplete block designs by Fisher and Yates has given a remarkable stimulus to the study and discovery of various types of difference sets. Singer, Bose and Chowla have discovered some remarkable properties and theorems concerning the difference sets. We set forth in this paper a calculus of difference sets, which utilises the present findings in this field and leads on to other interesting results. Our main contributions are briefly outlined below :—

1. In the notation of Fisher and Yates, if $v=b$, then $r-\lambda$ is a quadratic residue with respect to v and there exists only a finite number of designs for a given value of $r-\lambda$; for example, when $r-\lambda=11$, the only possible values for v are 43, 49, 79 and 133. Several significant facts are associated with the number $r-\lambda$ which must therefore be regarded as a very important function of the symmetrical block designs.

2. A necessary condition for a cyclic solution to exist is that $r-\lambda$ should be a perfect square when v is even. Hence a difference set does not exist when v is even and $r-\lambda$ is not a perfect square; as for example when $v=b=46$, $r=k=10$, $\lambda=2$.

3. There is no difference set consisting of cubic residues (or non-residues) alone with respect to a prime of the form $(3m+1)$. The case of quadratic, and biquadratic residues has been considered by Bose and Chowla. We wish to add that non-residues both quadratic and biquadratic also lead to difference sets. We have found certain necessary and sufficient conditions for the existence of $n-ic$ residues (mod. $pn+1$) (a prime number) leading to difference sets.

4. The problem of difference sets reduces itself to the construction of polynomials of the form $\sum x^a y^b z^c \dots$ such that

$$\sum x^a y^b z^c \dots \times \sum x^a y^b z^c \dots = \text{a constant.}$$

if $1=x^p=y^q=z^r=\dots$ and $x, y, z, \dots \neq 1$. One such instance is the following :—If $x^{10}=y^7=1$ and $f(x, y)=y^{x^9}+y^{x^6}+y^x(x^9+x^{18}+x^{14})+y^4x^4+y^5(x^2+x^4+x^{10})+y^9(x^3+x^8+x^{15})$

then $f(x, y) \cdot f(x^{-1}, y^{-1})=11$ when $x, y \neq 1$.

5. A difference set implies the existence of irregular cyclic polygons having the same lengths for sides and diagonals as in a regular polygon. In particular, there exist two quadrilaterals not congruent to one another, such that the sides and the diagonals of one occur in a different permutation of the other.

2. On the application of linear estimation to the general theory of the analysis of doubly classified heterogeneous material.

R. C. BOSE, Calcutta.

We consider uv stochastic variates y_{ij} , ($i=1, 2, \dots, u, j=1, 2, \dots, v$), with a common variance σ^2 , such that $E(y_{ij})=b_i+t_j$, n_{ij} observations

$$y_{ij}^{(l)}, l=1, 2, \dots, n_{ij}$$

being available for y_{ij} . Let

$$\sum_i n_{ij} = r_j, \quad \sum_j n_{ij} = k_i, \quad \sum_i k_i = \sum_j r_j = N, \quad \sum_{i,j} y_{ij}^{(l)} = T_j, \quad \sum_{i,j} y_{ij}^{(l)} = B_i$$

$$Q_j = T_j - \frac{n_{1j} B_1}{k_1} - \frac{n_{2j} B_2}{k_2} - \dots - \frac{n_{uj} B_u}{k_u}$$

The following theorems have been established :

Th 1. Corresponding to any parametric function $P = \sum_j l_j t_j$ containing the parameters t only, there exists a unique linear function $Y = \sum_j q_j Q_j$ of the Q 's such that $E(Y) = P$. This linear function Y is the best estimate of the parametric function P .

Th 2. $E(Q_j) = c_{1j} t_1 + c_{2j} t_2 + \dots + c_{vj} t_v$, $V(Q_j) = c_{jj} \text{Cov}(Q_j, Q_k) = c_{jk}$, where

$$c_{jj} = r_j - \sum_i \frac{n_{ij}^2}{k_i}, \quad c_{jk} = - \sum_i \frac{n_{ij} n_{ik}}{k_i}, \quad j \neq k$$

The concept of 'connectedness' is introduced, and the following theorem proved.

Theorem 3. For a connected system every contrast $C = l_1 t_1 + l_2 t_2 + \dots + l_v t_v$, $\sum l_i = 0$, is estimable. The best estimate of C is obtained by substituting in C , any set of values of t obtained by solving the normal equations.

$$\sum_j c_{1j} t_j = Q_1, \quad \sum_j c_{2j} t_j = Q_2, \quad \dots, \quad \sum_j c_{vj} t_j = Q_v$$

where c_{1j} and c_{jk} are defined in Th. 2. If these normal equations lead to

$$t_1 = \sum_j d_{1j} Q_j, \quad t_2 = \sum_j d_{2j} Q_j, \quad \dots, \quad t_v = \sum_j d_{vj} Q_j$$

then the variance of the best estimate of C is $\sigma^2 \sum_{j,k} l_j l_k d_{jk}$

Theorem 4. The sum of the parameters corresponding to any connected part is non-estimable. For a system which breaks up into N connected parts, unconnected with one another, the contrasts between the totals of the parameters corresponding to the different parts are non-estimable, so that the $N-1$ degrees of freedom belonging to these contrasts are confounded.

Appropriate tests of significance for hypotheses regarding one or more of the estimable contrasts between the parameters t , have been developed. Finally the general theory has been applied to the analysis of field experiments, including the analysis of balanced incomplete block' and quasifactorial designs', as well as the factorial designs' involving total or partial confounding.

3. The fundamental theorem of linear estimation for correlated variates.

R. C. BOSE, Calcutta.

Let y_1, y_2, \dots, y_n be n stochastic variates, whose expectations are linear functions of m unknown parameters p_1, p_2, \dots, p_m . Thus

$$E(y_i) = a_{i1} p_1 + a_{i2} p_2 + \dots + a_{im} p_m, \quad (i=1, 2, \dots, m)$$

Also let $V(y_i) = \sigma_i^2 = \sigma_{ii}$, $\text{cov}(y_i, y_j) = \sigma_{ij}$. Thus $\Delta = (\sigma_{ij})$ is the covariance matrix. A linear function

$$P = l_1 p_1 + l_2 p_2 + \dots + l_m p_m$$

of the parameters is said to be estimable if there exists a linear function.

$$Y = c_1 y_1 + c_2 y_2 + \dots + c_n y_n$$

such that $E(Y) = P$. Consistent with this condition it is required to find the best estimate of P , i.e. an estimate for which the variance is minimum. Let V be the vector space generated by the vectors

$$a_j = (a_{1j}, a_{2j}, \dots, a_{nj}), \quad j=1, 2, \dots, m$$

Any vector may be regarded as a matrix whose first column vector is the given vector and the other column vectors are null. Corresponding to any vector α we get a vector α' given by $\alpha' = \Delta^{-1} \alpha$, which may be called the derived. The derived vectors of the vectors of any vector space themselves constitute a vector space which may be called

the derived of the given vector space. The derived vector space of V may be denoted by $\Delta^{-1}V$. This vector space plays the part of the 'estimation space' in the corresponding theory for uncorrelated variates (Cf. the fundamental theorem of linear estimation. Proc. 31st Ind. Cong.). The following theorem which may be called the fundamental theorem of linear estimation for correlated variates has been proved.

Th. Given an estimable function $P = l_1 p_1 + l_2 p_2 + \dots + l_m p_m$ of the parameters, there exists one and only one vector $\gamma = (c_1, c_2, \dots, c_n)$ lying in the estimation space $\Delta^{-1}V$, such that

$$E(Y) = P, \text{ where } Y = c_1 y_1 + c_2 y_2 + \dots + c_n y_n. \quad Y \text{ is then the best estimate of } P.$$

4. A theorem on balancing.

R. C. BOSE, Calcutta.

The following theorem has been proved : For a factorial design of the class (S^m, S^{m-1}) i.e. a factorial design in which there are m factors each at $S = p^n$ levels (p is a prime), and each complete replication consists of S^{m-1} blocks of S plots each, we can find $(S-1)^{m-1}$ replications in which the main effects remain unconfounded, and a complete balance is achieved over interactions of all orders from the 1st to the $(m-1)$ th. The loss of information on any $(k-1)$ th order interaction, $k=1, 2, \dots, m$ is given by

$$\{(S-1)^{k-1} - (-1)^{k-1}\} / \{S(S-1)^{k-1}\}$$

The value $k=1$ corresponds to 0-th order interaction or main effects and the above formula shows that there is no loss of information in this case.

5. Functional relations in a Bessel Population.

P. K. BOSE, Calcutta.

The distribution of classical "D" Statistic was found to be

$$\delta\{\phi(p)\} = \frac{\tilde{n}p}{4} \left(\frac{\tilde{n}D^2 + 2}{\tilde{n}\Delta^2} \right)^{\frac{p-2}{2}} - \frac{\tilde{n}p}{2} \left(D^2 + \Delta^2 + \frac{2}{\tilde{n}} \right) \\ I_{\frac{p-2}{2}} \left[\frac{\tilde{n}p}{2} \sqrt{\left\{ \Delta^2 \left(D^2 + \frac{2}{\tilde{n}} \right) \right\}} \right] d(D^2).$$

By a suitable transformation the above form can be reduced to

$$\delta\{\phi(p)\} = \frac{Lp^2}{(\lambda)^{\frac{p-2}{2}}} \frac{1}{2} (L^2 + \lambda^2) \frac{I_{\frac{p-2}{2}}(L\lambda) dL}{2}$$

By suitably integrating we can show that

$$\phi(p) = -f_{p-2} + \phi(p-2)$$

$$\text{where } f_{p-2} = \frac{e^{-\frac{1}{2}(L^2 + \lambda^2)}}{\lambda^{p-2}} (\lambda L)^{\frac{p-2}{2}} I_{\frac{p-2}{2}}(L\lambda)$$

and $\phi(p-2)$ is a probability integral of a lesser order. f_{p-2} in its turn is again connected by a relation

$$f_{p-2} = \frac{L^2}{\lambda^2} f_{p-4} - \frac{p-4}{\lambda^2} f_{p-4}$$

The above are two relations connecting f and ϕ functions in a Bessel population.

6. On the sampling error in the method of double sampling.

(Mrs.) CHAMELI BOSE, Calcutta.

A variate, difficult of direct measurement and hence of direct estimation (from a sample), can sometimes be profitably estimated indirectly in terms of sample measurements of a concomitant variate (easier of direct measurement) provided that a regression

equation is known connecting the two variates. The regression equation is built up from a small sample in which both variates are measured (this being called the first stage sampling) and this is used to estimate the more difficult variate from a large number of sample readings of the easier (concomitant) variate (the latter being called the second stage sampling). This whole process of estimation may be conveniently called double sampling method and the difficult and easy variates as the first and second variates respectively.

At the background of the sampling procedure may be contemplated variation (i) in the first stage of (a) both the variates, (b) the first but not the second, and (c) the second but not the first, and variation (ii) in the second stage of (a) both the variates, (b) the first but not the second, and (c) the second but not the first. Anyone under (i) can be associated with any one under (ii) giving us thus altogether nine different situations.

In this paper for all the nine different situations algebraic expressions have been given (1) for the error of the estimate, and (2) for the expectation of the discrepancy between the unknown true sample mean of the first variate (at the second stage sampling) and the graduated sample mean of the first variate (obtained from the sample readings of the second variate at the second stage).

7. On a useful integral in problems of distribution in statistics.

M. C. CHAKRABARTI, Dacca.

A simple integral is given in the text by repeated use of which one can find out the distribution law of a large number of commonly occurring statistics among which mention may be made of (a) the mean of a random sample of size n from (i) a Type III population (ii) rectangular population (iii) Cauchy population (iv) exponential population, (b) the geometric mean of a random sample of size n from a rectangular population and (c) the statistic $u = x_1^p + \dots + x_n^p$ where x_1, x_2, \dots, x_n is a random sample of size n from the population $p(x) = \text{Const. } x^{p-1} \exp(-bx^p)$, where p and b are positive.

8. Remainders in quadrature formulae.

M. C. CHAKRABARTI, Dacca.

Among quadrature formulae there is a certain class called simplex where the remainder comes out in an elegant form. The paper investigates exhaustively a long list of quadrature formulae and a decision is arrived at by (i) direct inspection (ii) application of one of the four theorems established in the text (iii) breaking up in favourable cases into component parts each of which is simplex.

9. On the relative efficiency of two methods of estimating the proportion of individuals in a population having values below a specified level.

C. CHANDRA SEKAR and S. C. BHOWMIK, Calcutta.

In many fields such as the control of quality in industrial production and the assessment of the quality of dietary in a community the following problem arises :

A character representable by a continuous variable x is studied. The data collected consist of the values of x for a certain number of individuals drawn randomly from the population. It is required to estimate the proportion of individuals in the population with values of $x \leq x_0$, where x_0 is specified.

Two methods of estimation are in use.

(1) The proportion of individuals in the sample with values of $x \leq x_0$ is used as an estimate.

(2) The deviation of x_0 from the sample mean is reckoned in terms of the standard deviation as estimated from the sample and the area of the frequency distribution of x for $x \leq x_0$ is obtained by referring this deviation to the integral probability of the normal curve of error.

This paper attempts to compare the efficiency of these two methods of estimation.

10. Measures of heterogeneity and their inter-relation in agricultural and similar fields.

BIRENDRANATH GHOSE, Calcutta.

Harris (1915) proposed the intra-class correlation as a coefficient of heterogeneity, Smith (1938) proposes a fertility contour map, or the b -coefficient of variance and Mahalanobis (1944) proposes a variance function, correlation function and number of patches in a contour map.

Now, besides the quantitative differences the fields may be classified into three broad types (a) homogeneous, (b) heterogeneous and (c) random, which may be called conventionally (a) positive, (b) negative and (c) zero. All measures of heterogeneity should tally broadly if not in detail. The relation between correlation and variance is simple and so the relation between the correlation and contour maps has been taken up for study. For a linear field with binomial variate, it can be shown that the serial correlation with unit gap $\rho = 1 - \frac{\gamma}{2p(1-p)}$ where γ is the ratio of number of patches

to the number of cells and p is the proportion of the binomial character. This is strictly true if we make the chain endless by linking the last cell with the first. For the actual sequence some correction is necessary, which is negligible if the number of patches (or cells) is large. The sampling distribution of ρ for random fields have also been worked out.

For multinomial or two-dimensional fields there can be no such unique relation, but broad correspondence can be established. Further theoretical and experimental studies are being continued.

11. Test for field uniformity based on the space correlation method.

M. N. GHOSH, Calcutta.

The space correlation has been introduced by Professor Mahalanobis for characterising two dimensional fields. Like the serial correlation in the one dimensional case the space correlation may be used for testing the uniformity of a field. In this paper the first four moments of the distribution of space correlation for a given gap is determined when the universe of sample variation is limited to certain permutation set of an observed field. The test so obtained is nonparametric and is valid for any *a priori* distribution of the elements. It has also been shown that these moments statistically converge to the moments of a normal distribution for large fields and approximate tests may be done based on this property.

12. Tests of hypotheses for more than one free parameters.

M. N. GHOSH, Calcutta.

Tests have been devised by Neyman and Pearson for the case of more than one parameters which are called regular and non-regular unbiased critical region of type C. These involve some arbitrary elements as they are not invariant for a transformation in the parameter space. In this paper suitable criteria have been developed by utilising the notion of distance of two statistical populations due to Bhattacharya, which are free from the above limitations. Some large sample properties of this distance function have been studied from the point of view of statistical tests.

13. A simple method for the derivation of the distribution of the generalized variance of normal-multivariate samples.

P. V. KRISHNA IYER, New Delhi.

It is known that the generalized variance $|a_{ij}|$ of an n -variate sample is equal to $S^2_{11} S^2_{22} \dots S^2_{n-1, n-1}$. The ratio of the generalized variances on the basis of a_{ij} ,

between and that for all the samples together is equal to $\frac{S^2_{11} S^2_{22} \dots S^2_{n-1, n-1}}{S'^2_{11} S'^2_{22} \dots S'^2_{n-1, n-1}}$

where $S^2_{11} S^2_{22} \dots S^2_{n-1, n-1}$ and $S'^2_{11} S'^2_{22} \dots S'^2_{n-1, n-1}$ refer to the respective residual variances after fitting regression equations for within and all the samples together. (S^2_{11} is based on the size of samples and not on the degrees of freedom).

The distribution of $\theta_r = \frac{S^2_{r+1, r+1} \dots S^2_{n-1, n-1}}{S'^2_{r+1, r+1} \dots S'^2_{n-1, n-1}}$ is

$$B \left\{ \frac{p-1}{2}, \frac{n}{2}, \frac{\sum_{i=1}^n N_i - p - r + 1}{2} \right\} \theta_r^{\left(\sum_{i=1}^p N_i - \frac{p-r+1}{2} - 1 \right)} (1-\theta_r)^{\frac{n-1}{2} - 1} d\theta_r$$

N and p stand for the size of the r th sample and the number of samples involved in the analysis.

Hence the distribution of the ratio of the generalized variances is the same as that of

$$\prod_{r=0}^{n-1} \theta_r \quad \text{obtained from}$$

$$K \prod_{r=0}^{n-1} \theta_r \left(\sum_{i=1}^n \frac{N_r - p - r + 1}{2} - 1 \right) \dots \frac{p-1}{2} - 1 \quad d\theta_r,$$

The method of integrating the above expression has been dealt with by Wilks in *Biometrika*, 24, p. 475.

14. On a certain distribution in the theory of sampling.

K. V. KRISHNASASTRY, Mysore.

From a very large univariate Normal Population with zero mean and standard deviation σ , i samples containing n_1, n_2, \dots, n_i individuals with means m_1, m_2, \dots, m_i and variances S_1, S_2, \dots, S_i , are drawn. In this paper the distribution of

$$(\sum \alpha_i m_i) / \sqrt{\sum n_i S_i^2}$$

has been derived by the use of characteristic functions. The theorem by Harold Simpson in *J. R. S. S.* 1943 p.266, has been deduced as a special case.

15. On the power function of the Studentised D^2 -statistic.

H. K. NANDI, Calcutta.

The studentised D^2 -statistic is used to test the significance of the statistical hypothesis regarding the equality of means of p characters of two multivariate normal populations having the same dispersion matrix, for which uniformly most powerful test does not exist. The optimum properties of this test have been studied and it is found that the critical region of size α given by $D^2 \geq D^2_\alpha$ is (i) a valid test of the hypothesis under consideration, (ii) uniformly unbiased and as such gives the highest success rate, and (iii) of the greatest resultant power for a particular apriori distribution of the admissible alternatives which makes the test uniformly most powerful among those critical regions which involves a single parametric function Δ^2 . In view of the properties noted above, further support is given to the single parameter Δ^2 as a measure of divergence between two statistical populations differing in respect of means only.

Incidentally, the ordinary tests of simple correlation, simple regression, multiple correlation and multiple regression have also been studied and their optimum properties found out.

16. On the distribution of the mean of the extreme values in samples from a Normal population.

K. C. S. PILLAI, Trivandrum.

In this paper, the distribution of the mid-point, M , of the range in samples of size n from a normal population has been reduced to a convenient form which can be readily put to numerical calculations. It is proved that

$$P(M) = \frac{-M^2}{[n(n-1)/\pi]} e^{-(B_0 + B_1 M^2 + B_2 M^4 + \dots)} - \infty < M < \infty$$

where B_0, B_1, B_2, \dots may be evaluated from certain recurrence relations. The rapidity of convergence of this series is very high so that only first few terms alone are required in numerical computations.

17. On a test of equality of association in two contingency tables.

S. JANARDHAN POTI, Calcutta.

In a 2×2 contingency table for any given marginal distribution the internal distribution depends only on one parameter which is the ratio of the cross products of the cell frequencies in the population. In the case of independent distributions

$\psi=1$. Departure of ψ from unity measures the degree of association. To test the equality of association is equivalent to testing the equality of ψ 's. In the case of large samples the maximum likelihood estimate is equal to the ratio of the cross products of the frequencies and a test is easily obtained based on the standard errors of the maximum likelihood estimates. But in the case of small samples an exact test has been obtained based on the relative probability of x , the lower left hand cell frequency of one of the contingency tables, when the joint internal distribution of the two samples are known. If x_1, x_2 are the lower left hand cell frequencies of the two contingency tables then the relative probability of x_1 given $t=x_1+x_2$ is

$$\frac{C_{x_1} C'_{t-x_1}}{\sum C_{x_1} C'_{t-x_1}} \text{ where } C_{x_1} = \frac{1}{(n_1-x_1)! x_1! (n_1-n_1+x_1)! (n_2-x_1)!}$$

$$C'_{x_2} = \frac{1}{(N_1-x_2)! x_2! (N_1-N_1+x_2)! (N_2-x_2)!}$$

More generally in the case of $2 \times n$ table the internal distribution will depend only on $(n-1)$ parameters $\psi_1, \psi_2, \dots, \psi_{n-1}$ which will all reduce to unity in the case of independent distributions and on similar lines exact tests have been obtained though the labour involved in testing increases.

18. On a test of the efficacy of a treatment when all treated elements are not similarly chosen

S. JANARDHAN POTI, Calcutta

There are K mutually exclusive classes and π_1, π_2, π_3 are truncated populations derived from the original population π by cutting off none of the classes, the 1st class, the 1st and 2nd class, etc. N_1 elements are chosen at random from π_1 , and N_2 from π_2 and so on and to the combined sample the treatment is applied and joint distribution of the $N=N_1+N_2+N_3+\dots$ elements only are known. Our problem is to test the efficiency of the treatment on the basis of such observations. The controlled groups provide the estimates of the expected frequencies for the treated groups. In the case of large samples a test has been devised by obtaining the covariance matrix of the (observed—estimate of the expected) of the treated groups.

19. On the problem of k samples and k multivariate populations with unequal variances and covariances.

C. RADHAKRISHNA RAO, Calcutta.

It is well known that the tests of significance of the null hypothesis connected with univariate or multivariate normal populations with identical variances and covariances depend upon the distributions of t , F and some symmetric functions of roots of determinantal equations. It has been shown that exact tests of significance can be carried out with the help of these distributions only even when the variances and covariances are not equal. In particular the following problems have been considered.

- (1) Analysis of variance in the case k unequal samples from k populations with unequal variances (but unknown) has been given.
- (2) The test of equality of means of p variates with an unknown dispersion matrix has been found out.
- (3) The general problem of D^2 connected with two multivariate normal populations with unequal dispersion matrices (unknown) has been discussed.
- (4) The problem of discriminating k multivariate populations on the basis of the mean values alone is done with the roots of determinantal equations analogous to those known in statistical theory in the case of equality of variances and covariances for all the populations.

20. Distance between two populations for discrimination and classification.

C. RADHAKRISHNA RAO, Calcutta.

Given the type of the distribution function $f(x_1, x_2, \dots, x_r; \theta_1, \theta_2, \dots, \theta_k)$ of r stochastic variates x_1, x_2, \dots, x_r defined with respect to k parameters $\theta_1, \theta_2, \dots, \theta_k$ we can represent it by a point $(\theta_1, \theta_2, \dots, \theta_k)$ in a k dimensional space which is termed as the

population space. The element of length ds between two consecutive points $(\theta_1, \theta_2, \dots, \theta_k)$ and $(\theta_1 + d\theta_1, \theta_2 + d\theta_2, \dots, \theta_k + d\theta_k)$ in this space is defined by the quadratic differential metric

$$ds^2 = \sum \sum g_{ij} d\theta_i d\theta_j$$

where g_{ij} are elements of the information matrix defined by

$$g_{ij} = -E \left\{ \frac{\delta^2 \log f}{\delta \theta_i \delta \theta_j} \right\}$$

which constitute the elements of a symmetric covariance tensor. The distance between two points A, B in this space is obtained by integrating the line element along a geodesic through A and B.

The use of the measure of distance in large and small sample tests of significance have been discussed and also its role in the general problem of classification.

21. Further studies in multivariate analysis of variance.

S. N. Roy, Calcutta.

The joint sampling distribution (on the null and next on the non-null hypothesis) and later on, the individual sampling distribution (on the null hypothesis) of a set of p-statistics suitable for multivariate analysis of variance had been earlier obtained by the author. The joint distribution on the non-null hypothesis involved only one function of the population parameters (en bloc) which plays a significant part in the whole theory. At the last session of the Indian Science Congress a paper was offered by the author, in which was sketched a method of obtaining on the non-null hypothesis the individual sampling distribution of the different statistics. The present paper derives the distribution (on the non-null hypothesis) of each statistic fully and in particular that of the maximum and the minimum. A chain of connections and relations between the distributions of the different statistics is also exhibited.

22. On the power functions of the different p-statistics for multivariate analysis of variance.

S. N. Roy, Calcutta.

Starting from the individual sampling distribution (on the non-null hypothesis) of the p-statistics appropriate for multivariate analysis of variance already obtained by the author, it is shown in the present paper that the maximum statistic (or the largest latent root in another language) leads to a test which among all the roots or linear functions of such roots happens to be the most powerful test (on an average) or the uniformly most powerful test among all statistics whose distributions involve only a particular function of the parameters. In the averaging mentioned just now radial symmetry is assumed when weightage is given to deviations from the null-hypothesis, the deviations being first taken in a canonical form.

23. On the individual sampling distributions of p-statistics for testing equality of the dispersion matrices for two multivariate normal populations.

S. N. Roy, Calcutta.

The joint sampling distribution (on the null and then on the non-null hypothesis), and next the individual sampling distribution of a set of p-statistics had been earlier obtained by the author for purposes of testing the hypothesis of equality of dispersion matrices for two multivariate normal populations. In the present paper the author has obtained in full on the non-null hypothesis the individual sampling distribution of these statistics. The distribution of each involves the same set of p functions of population parameters (or simply p population parameters in a canonical form); the maximum and the minimum statistic play a special rôle discussed in the paper and a whole chain of relations between the p different distributions is brought out.

24. Method of curve fitting by minimizing χ^2 .

E. R. SUNDARARAJAN, BANGALORE

Agricultural Statistics

25. An approximate method for forecasting the yield of *Aman* paddy.

P. K. BOSE, Calcutta.

In studying the period of rainfall in Calcutta from (1900-1939) we have found that $y = a + bt + ct^2$, where y is the weekly total of rainfall in inches and t is the time, is a suitable formula for graduation. From the above graduation formula we can find out the date of maximum rainfall for each year as $t = -b/2c$. We can define "mean incidence of rainfall" as $t = \frac{\sum y_1 t_1}{\sum y_1}$. For each year we can calculate t .

Thus for each year we are getting two dates

(1) t_{\max} (2) t_{mean}

Now it is suggested that in those years where t_{\max} is very nearly equal to t_{mean} there is a chance of good crop.

26. The Effect of inorganic fertilisers on the yield and growth of rice plant.

P. K. BOSE, Calcutta.

Part one is a pot culture experiment. Niciphos with 10 different doses has been tried to study the growth of the rice plant in 10 different earthenware pots. The experiment has been designed as a randomised block with 6 replications. It has been found that there is an optimum dose viz. $\frac{1}{2}$ tola of manure per 20 srs. of soil; after this if the dose is increased, there is very slight difference in growth. This above dose is significantly different from control. Part two deals with an experiment which has been carried on field. The following manurial dressings have been tried: (1) Potash as Sulphate at the rate of 130 lbs per acre (2) Magnesium as Sulphate at the rate of 82 lbs per acre (3) Niciphos at the rate of 130 lbs per acre.

27. Lime in two different doses.

P. K. BOSE, Calcutta.

The experiment has been designed as a split plot one, with lime as sub-plot treatment and Magnesium, Potash and Niciphos as whole plot treatment. The conclusion from the above experiment is that Potash, lime and Magnesium have given no appreciable increase in yield whereas Niciphos alone has given a significant increase in yield.

28. A direct method of estimating total production of crops.

P. C. MAHALANOBIS, Calcutta.

Production from any crop depends on two factors: (1) the area under the crop, and (2) the yield per acre. If we have a 'complete census' of the crop-area then the total production can be obtained by multiplying the area harvested by the yield per acre as estimated by crop-cutting experiments.

This procedure introduces certain uncertainties due to ambiguities in the definition of crop-area. For example, sowings (especially in rain-fed crops) depend a great deal on the distribution of rainfall, and 'area sown' fluctuates from time to time. 'Area harvested' is also not the same as the 'area sown' and is usually smaller and may be very much smaller in a bad season. Further, the area occupied by ails (field boundaries) have also to be eliminated.

These difficulties can be avoided by adopting the grid or areal method of sample survey. The total geographical area is divided into a number of 'grids', and a suitable number of grids are chosen at random and directly surveyed in respect of (1) area under various crops, (2) 'area harvested' for any crop, (3) area occupied by ails, and (4) the yield, per acre (which is usually ascertained by direct crop-cutting work on smaller samples selected at random within the grid).

From the information so collected, an estimate of average production per grid is directly calculated and the estimate of total production is obtained by multiplying this figure by the number of grids in each zone. Estimates of total production for different geographical units are then easily built up. This method is being actually used in the Bengal crop survey scheme since 1943 and further researches are in progress for improving the technique.

29. On finding the critical months of rainfall and their effect on the yield of wheat per acre in important wheat growing districts of the United Provinces.

A. R. SEN, Lucknow.

In this paper a study has been made of the effect of the distribution of rainfall over a period of 7 months, from October to April ranging over a period of 40 years. A multiple regression of yield on monthly rainfall was fitted to obtain the critical months after eliminating the yearly trend by fitting orthogonal polynomials of the fifth degree to the figures of yield and monthly rainfall. A study of the combined effect of critical months with similar effects was next made.

Economic Statistics

30. Tentative estimate of the extent of starvation among the landless workers of Bengal according to different values of an Index.

B. C. BHATTACHARYA, Krishnagar.

The economic data which will make available a fully reliable income-distribution curve of landless families of Bengal are perhaps not available. Tentative distribution curves for *normal* times have therefore been obtained on the basis of a few data taken from the census reports. For different values of an Index (which depends on the ratio of the Index of wages and the Index of the price of rice) the number of families which fall below subsistence level has been calculated from the distribution curves and so the percentage of the people below starvation level obtained from a number of tables so calculated, one is put forward tentatively as possibly representing the true state of things in Bengal.

31. A new approach to the theory of demand.

N. K. CHAKRAVARTI, Calcutta.

In this paper an attempt has been made to build up a theory of demand which takes into consideration variations in income distribution. The community is classified into a certain number of groups the individuals in a group having the same tastes and preferences. The income distribution $v_i(I)$ of a group i will be more or less normal. Determining the Engel curves $E_{it}(I)$ for the groups at times t from sets of budget data, total demand is obviously $\sum_i \sum_t v_i(I) \cdot E_{it}(I) \cdot N_{it}$ where N_{it} is the number in group i at \sum_t

$$\sum_i \sum_t v_i(I) E_{it}(I) N_{it}$$

time t .

We suppose that there is intergroup movements of individuals with time, but the $v_i(I)$'s remain the same. Let us suppose

$$N_{it+1} = N_{it} + x_{it}$$

Then

$$I_i \sum_t x_{it} = \gamma_{t+1} - \gamma_t \quad (2)$$

where γ is the total population at time t . If R_t is the total National income at time t , we have

$$\sum_t x_{it} \cdot I_i = R_{t+1} - R_t \quad (3)$$

where I_i is the mean income of the group i . We now define a function $\phi(x^1, x^2, \dots, x^m)$ representing best group distribution. ϕ may be taken to be a linear function, the coefficients of the x 's being the average productivity of the corresponding groups. We determine the x 's so that the welfare of the community is a maximum. For this we maximise ϕ with restraining conditions (2) & (3) when we have got the x 's we can get the demand at once from (1). The productivities may be graduated by smooth periodic curves depending only on time. The Engel curve depends on prices of all commodities and population depends on business out look and total productivity. Thus all the factors affecting demands are incorporated.

32. A note on the oscillatory movements in foreign trade of India.

K. V. KRISHNASASTRY, Mysore.

The older methods of detecting periodicity in time series are not suitable to most of the economic series. Following Yule and Kendall, autoregressive analysis has been applied to the foreign trade of India. The data are taken from a paper by Messrs. N. Sundara Rama Sastry and N. T. Mathew. It is shown in the present paper that the foreign trade of India shows *damped oscillatory movements*, which are regenerated by external influences in the case of exports. The fundamental period is about 6 years for both the series. While the authors of the above paper arrived at two periods, the present analysis does not show more than one period. The minor period of 6 years for the export trade agrees with the fundamental period, while that for the import trade is 7 years against the fundamental period of 6.3 years.

33. A family budget enquiry at giridih in Bihar

N. T. MATHEW, Calcutta

From among the total number of the about 8000 families resident within the municipal limits 450 families were selected (from the municipal lists) and the details of family composition, income, and pattern of expenditure were noted for each of these families. The results of statistical analysis of the material thus obtained are given in this paper.

Vital Statistics

34. Reproductive wastage and infant mortality as obtained from the records of some Maternity and Child Welfare centres in Calcutta.

C. CHANDRA SEKAR, Calcutta.

As a routine the Maternity and Child Welfare centres in Calcutta run by the Red Cross and the All-India Institute of Hygiene and Public Health, maintain records of the histories of the previous pregnancies of expectant mothers attending the clinic. The data are primarily intended to assist in determining the extent of antenatal care required by each individual and are usually recorded by trained health visitors. For obvious reasons records of previous pregnancies are not so accurate or illuminating as those relating to pregnancies under care. Yet the analysis of these records can give a broad picture of past vital happenings in the section of the community represented by those attending the clinic.

In this enquiry the data of 21,473 pregnancies relating to 5,939 women who attended one of four centres in Calcutta during the period 1936-40 were analysed to give the incidence of abortions and still births amongst them. The influence of factors such as parity, province of origin and occupations of parents on reproductive wastage was also assessed. The relative frequency of abortions at various levels of gestation was also worked out. The neonatal and infant mortality rates of viable births were calculated and the influence of various factors including parity and sex on infant life was also considered.

35. Studies in the health problems of a rural community in western Bengal. Part I. Population problems.

K. K. MATHEN and R. B. LAL, Calcutta.

A house to house health survey of a random sample consisting of 7058 individuals, belonging to 1197 families, drawn out of a total population of 62700 persons living in 68 villages, in Singur Health Centre Area, has been carried out. Certain aspects of population problem are presented. The age and sex constitution of the sample population as also the civil condition closely resemble Bengal as a whole. These have been contrasted with the population of Japan, England and Wales. Other points discussed include, the social factors in relation to age at marriage and the trend of its variation, live-birth, abortion, and still-birth rates, seasonal variation in pregnancy, fertility in relation to social factors, morbidity and mortality factors concerning the growth of population and the social aspects of the problem of population and its growth.

36. Growth of population in British India.

K. NAGABHUSHANAM and V. NARASIMHAMURTHY, Guntur.

Messrs. T. Krishnamurty and R.S. Krishnamurty estimated (Sankhya Vol.5 1940-41 page 279) the population of India for 1941 by 3 methods, viz :—

- (1) Fitting a parabola (2) Fitting the logistic, and (3) Biostatistical method, (using the figures of the survival rates).

The object of this paper is to compare their estimates with the observed values and examine the applicability of their methods to the British Indian provinces.

- It is found (1) that the population is not growing at a steady rate in any province; (2) that in the provinces of N.W.F., Bengal, Sind, Punjab, U.P., Bihar and Madras the growth during 1931-41 is more rapid than in the others and also more than that during the period 1921-31; and (3) that the Biostatistical method may be expected to be most fruitful for estimating the population of the above provinces in 1951 while the parabolic method appears best suited for the remaining provinces.

37. On the formation of homogeneous groups of districts from small-pox mortality in the United Provinces.

A. R. SEN and N. C. GUPTA, Lucknow.

An attempt has been made in this paper to form homogeneous patches of districts from small-pox mortality for the United Provinces by analysing the mortality data ranging over a period of 40 years (1901-1940) for all the 48 districts of the United Provinces. As on theoretical grounds the application of the technique of Analysis of Variance direct to such data is open to objection, the appropriate transformation has been worked out for the purpose of equalising the district variances and reducing the observations to a scale, in which the district means and variances are uncorrelated. The data was next analysed and homogeneous groups of districts from smallpox mortality obtained.

General

38. On an empirical method of fitting two parameter family of curves to observational data.

S. JANARDANA AIYER, Trivandrum,

In this paper, an empirical method to estimate the parameters in a class of two parameter family of curves of graduation, with special reference to the members of the Pearsonian system, has been worked out. For the Pearsonian curves, the points of inflexion are placed at equal distances on either side of the mode and the method is based upon the estimates of the points of inflexion and the relation they bear to the parameters in the equation to the curve and is applicable to the fitting of any unimodal curve having high contact with the axis of x at the end points. The method is illustrated by means of a number of examples and has been found to yield very good estimates of the parameters.

39. Analysis of the mileage run per gallon of petrol by various types of motor vehicles of one make on different types of road surfaces.

S. A. HAMID, Simla.

Data : The data regarding petrol consumption by four types of motor vehicles of one make over four types of road surfaces represents the experience of over sixty motor transport companies operating in British India.

Method The number of observations available for the different vehicle surface groups is not the same so the method of analysis of variance in the ordinary form could not be applied to means of different groups and the error estimated from all the observations was suitably adjusted for comparison with variances of group means.

Conclusions : (a) In regard to petrol consumption there are significant differences in road surfaces, which indicates the necessity of improving road surfaces, decreasing road gradients, and eliminating interruptions in traffic for reducing petrol consumption and thereby reducing the costs of transportation.

- (b) Interaction between surfaces and vehicle types is not significant.
- (c) There are significant differences between buses and lorries, buses consuming less ;
- (d) Post 1940 models of buses and lorries give better performance than pre-1940 models but the differences are not significant.
- (e) General averages obtained for buses and lorries with 3 ton chassis are 12.3 and 10.8 miles per gallon respectively.

40. Effect of population and produce on road development.

S. A. HAMID, Simla.

Data : The existing roads in the country are the result of interplay between numerous factors affecting road development. The effect of population and produce may then be looked for in the varying road milages existing in various provinces. Only that part of produce, which comes on roads, need be compared to road mileage. The produce consumed by rural population on the spot has, therefore, been excluded.

Results : There is a significant correlation between produce and road mileage (.793), and also between population and road mileage (.921). Partial correlation between produce density and mileage density is .105, and that between population density and produce density is .448, which though insignificant may prove stable in view of the comparative stability of density figures.

Conclusions :

- (i) The role of population, productive area, and total area is quantitative i.e. they have resulted in and create need for more road mileage. The corresponding role of produce is essentially qualitative i.e. it create need for better roads.
- (ii) As population is definitely on the increase, and produce density is hardly keeping pace, road extension deserves priority over road improvement in the programme of road development.
- (iii) The repercussions of other developmental programmes on road development may be viewed according to their effect on population and produce.

41. The optimum service period for maximum milk production in Sahiwal cows.

P. V. KRISHNA IYER, New Delhi.

On the basis of lactation curves for 4 times milking for the periods calving to service and service to drying it has been shown that the milk yield for a lactation period of 305 days is a maximum if the service period is about 11 weeks. The milk yield is maximum for life time if the service period is near about 7 weeks, the lactation period being 305 days.

42. An experiment on the construction of random numbers

N. T. MATHEW, Calcutta.

An experiment was conducted to find out whether it is possible to produce random sampling numbers by repeating the digits 0 to 9 in a haphazard manner. Between 1000 and 1500 digits were taken down from each of ten persons who had varying degrees of statistical experience, and hence a more or less satisfactory notion of what constitutes a set of random sampling numbers. It was found that in no case do the numbers satisfy even the simplest tests of randomness. All the subjects were found to be strongly biased in favour of particular digits. The average speed of dictation of such 'random numbers' was about 100 per minute.

43. Ranking of workers in a loom shed.

G. D. MATHUR, Ahmedabad.

It is a well recognised principle of psychology that if a suitable reward is given to a few persons working among a group of individuals in order of merit, the system tends to give stimulus to the whole group to improve their work qualitatively and quantitatively. In a loom-shed workers have to do tasks which require varying degrees of

abilities depending upon the nature of the sort (mixing, warp/weft, reed/pick, etc.) and the nature of the loom (width, make and revolutions, etc.). An attempt is, therefore, made to make homogenous groups of sorts and looms in which the productions as given by different workers in particular groups follow the normal law and workers giving productions above $(m+\sigma)$ are rewarded and intensive supervision is kept on the machines and workers giving productions lower than $(m-1.65\sigma)$. A system is then devised to rank the Jobbers (under whom a number of workers work on different types of sorts and on different types of looms) taking $(m+\sigma)$ as the standard of production for any sort in which the productions are distributed according to the normal law and a bonus is given to the first few Jobbers.

44. Time and motion studies in a loom shed.

G. D. MATHUR, Ahmedabad.

A random sample survey has been made of a loom shed by observing the machines and men on random times. The different causes of loom breakages and the various types of duties performed by the workers are recorded at any given random instant. On analysis of the result it is found that for any homogenous group of looms and sorts the total breakages follow the binominal law and the warp breakages follow the Poisson distribution. The number of total readings were so arranged that the standard error of the mean was reduced to about 1 per cent. These results are further utilised in making technological improvements in the loom-shed in order to get more productions.

45. Determination of best T. P. S. for different types of cottons.

G. D. MATHUR, and B. SARKAR, Ahmedabad

A simple experiment was devised to find out differences in five different types of cotton each one spinning 19's weft with four different turns per inch. It is found that there are significant differences in cottons as measured by their count strength values (which are known to be normally distributed for all practical purposes). The analysis of variance also shows that the interactions between cottons and turns per inch are significant which gives us a standard method for determining the most suitable turns per inch for a given variety of cotton spinning a given count.

46. A statistical investigation of B.A. B.Sc. and M.A. M.Sc. examinations in mathematics and geography of Aligarh Muslim University.

SYED TAQI MOHAMAD NAQVI, Aligarh.

I have analysed the results of students appearing at Master's Degree examination and their corresponding performance at the Bachelor's Degree examination, and, on the whole, it is found that in Master's Degree examination the performance of science students is of distinctly better type than that of arts students. But when the performance of students with equally good results at Bachelor's Degree examination is considered (by the application of χ^2 -test) there appears no reason to suppose that a science student will fair better (or worse) than an Arts student with equally good performance in B.A. and B.Sc. Contingency tables of B.A.-B.Sc. and M.A.-M.Sc. results are constructed and χ^2 -test reveals a good degree of positive association. Co-efficient of correlation and lines of regression are also worked out to support the contention that a better performance in B.A.-B.Sc. is positively associated with better performance in M.A.-M.Sc.

47. On the most efficient designs in weighing.

C. RADHAKRISHNA RAO, Calcutta.

There are p objects to be weighed and n weighments to be made. In case there is bias in the scales this may be considered as an additional weight. It has been proved that p , the number of objects including bias for the best possible design is less than or equal to $2s$ when n , the number of weighments is of the form $2s(2m+1)$. In this case the weight of each object including bias is estimated with variance σ^2/n and the estimate of σ^2 is based on $[2s(2m+1)-p]$ degrees of freedom. The best possible designs when there exist linear relations among the weights have also been investigated. An important case of this is when an object of known weight gets broken and the weights of separate pieces are required.

SECTION OF PHYSICS

PRESIDENT : PROF. S. BHAGAVANTAM, HON. D.Sc., F.A.Sc.

Crystal Physics

1. Elastic constants of tourmaline.

D. SURYANARAYANA, Guntur.

The elastic constant C_{33} of tourmaline, a piezo-electric crystal belonging to the class C_{3v} , has been determined for a number of Indian and American Specimens. The ultrasonic velocity along the principal axis is determined from the fundamental frequency of the longitudinal mode of a plate cut perpendicular to the axis, as detected by the diffraction of light by ultrasonic waves. The elastic constant is deduced from the density of the plate and the velocity as determined above.

2. Three types of extra reflections in Laue photographs.

K. BANERJEE, Calcutta.

Extra reflections that appear in over-exposed Laue photographs of crystals can be divided into three distinct types. The characteristics of the first type that has been observed in diamond, phloroglucine dihydrate and benzil crystals are that

- (1) these reflections are extremely sharp,
- (2) the positions of the spots are obtained by the assumption of derangement waves of continuous and extended frequency spectrum lying accurately along definite crystallographic directions. (linear derangement waves),
- (3) a few of the reflections according to the above rule but obeying certain regularities are absent.
- (4) there may occur variants of the crystal that do not show this effect.

The second type of extra reflections has been studied in benzil only and the characteristics of this type of reflection are as follows :—

- (1) On the Laue photographs this type of extra reflections appear as sharp lines lying in positions of layer lines for rotation about certain crystallographic axes.
- (2) The positions of the layer lines indicate that they originate from a set of derangement waves that lie accurately parallel to a definite set of equivalent crystallographic planes (planar derangement waves).
- (3) The equatorial lines are absent.

The third type is the more usual type of extra reflections which are obtained in Laue photographs of any substance. The following characteristics distinguish them from the other two types :—

- (1) They are essentially diffuse
- (2) The intensities fall off rapidly with increase of deviation from Bragg position.
- (3) They are produced when an X-ray beam is incident at a glancing angle close to the Bragg angle for any crystallographic plane.
- (4) The derangement waves that are responsible for them lie over all directions of space. (Spatial derangement waves).

3. Magnetic properties of single crystals of copper salts at low temperatures.

BHAGAWATI CHARAN GUHA, Dacca.

The principal magnetic susceptibilities of a number of copper salts have been measured from room temperature down to 80°K. These salts, as judged by their magnetic properties, fall into three distinct classes. In the first class all the principal susceptibilities follow the Curie law, but with different Curie constants; that is, the effective moments are different for different directions, but all of them are practically independent of temperature. To this class belong the Tutton salts. In the second class the moments are nearly the same as before, but they all decrease with the lowering of temperature, slowly at first and rapidly at later stages. The double chloride of copper and ammonium is a typical example of this class. To the third class belongs cupric acetate monohydrate, in which the principal moments are all very low even at room temperature and decrease rapidly as the temperature is lowered. The three classes correspond to the non-cubic part of the crystalline field being very different, lowest in the first class and highest in the third.

4. Magnetic behaviour of Ni^{++} salts from room temperature to 80°K.

BHAGAWATI CHARAN GUHA, Dacca.

Nickel salts deviate much from the S-state behaviour, as the spin-orbit coupling in Ni^{++} is quite large. This leads to an appreciable magnetic anisotropy and deviation from the Curie law. These deviations have been utilized to calculate the crystal field constants. It has been found that not only the cubic part of the field which is predominant but even the rhombic part which is small, is nearly the same in most of the nickel salts and they are practically independent of temperature.

5. Specific heats of Zn and Cd on Raman's theory.

BISHESWAR DAYAL and R. S. SHARMA, Benares.

Raman's theory of crystal vibrations gives thirteen distinct frequencies of atomic movement for the hexagonal metals Zn and Cd, the evaluation of which is rendered more difficult, on account of lower symmetry, than is the case with the metals crystallising in the regular system. In the latter case, it was found by one of us (Dayal, *Proc. Ind. Acad. Sc.*, 1944, 20, 24) that three out of the four optical frequencies could be obtained on dividing the appropriate elastic wave velocity with the corresponding wave length and multiplying the result by a dispersion factor $2/\pi$, a factor which was originally obtained by Born and Karman (*Phys. Zeits.*, 1912, XIII, 297) and later used by Grunisen and Goens (*Zeits. f. Phys.*, 1924, 26 24). We have assumed that all the frequencies of Zn and Cd can be obtained in the same way. Whereas Raman's theory gives six frequencies for the vibrations of the prismatic planes, the present method gives only three, which have been taken to represent all the six. Specific heats have been evaluated from these frequencies, the elastic spectrum having been represented by a Debye function obtained from Hönnefelder's work (*Zeits. f. Phys. Chem.*, 1933, 21, 53) in the manner adopted in the earlier papers. There is a satisfactory agreement between the calculated values and the experimental data. The maximum difference at any single temperature does not exceed 5% in the case of Cd and 15% in the case of Zn. This is ascribed to the fact that each frequency of vibration of the prismatic plane represents an average of two frequencies one larger, and the other smaller. It is shown that on substitution of actual frequencies the discrepancy is likely to disappear.

6. Normal frequencies of diamond.

T. VENKATARAYUDU, Guntur.

Normal Frequencies of the Diamond Structure have been previously given by Prof. S. Bhagavantam. In the present paper the same results are obtained by a slightly different method.

Electricity and Magnetism

7. The new law of dipole moments.

S. K. K. JATKAR, Bangalore.

It was shown that owing to polarisation being maximum in the direction of each bond and molecular and intramolecular rotation, electric moments of polyatomic molecules are not given by vector but by component law. When such rotations are hindered as in ionic solids and associated liquids and in molecules with double bonds the moments are correctly given by vectors. Thus H_2O molecule has a moment 1.87 in vapour and 3.0 in ice, the OH bond moment being 2.5D in each case corresponding to $\frac{1}{2}$ ionic character. The moments of divalent ionic cubic solids are $\sqrt{2}$ times the AX bond moment, being vectors.

8. Dielectric constants and dipole moments of polar liquids.

S. K. K. JATKAR, Bangalore.

In the present paper the author has derived the simple relationship between the dielectric constants of polar liquids and solids and the dipole moments on the basis of postulates inherent in previous theories of dielectric behaviour and compared the new equation with those proposed by Debye, Kumbler, Wyman, Onsager and recently by Frölick and Sack. The new equation is capable of further improvement and refinement as further data on not only dielectric constants but on allied subjects such as molecular spectroscopy, x-rays and light scattering are made available.

9. Bond moments and electronegativity.

S. K. K. JATKAR and N. V. SATHE, Bangalore.

Owing to the unexpected developments in the theory of dielectric constants and dipole moments, the value of bond moments and the ionic character of bonds have undergone substantial changes. In the present paper the authors have shown that the ionic character of bonds reaches a limiting value with increasing electro-negativity differences. The results are discussed in light of recent theories of Samuel and Wheland.

10. Diamagnetism and feeble paramagnetism of solids.

S. K. K. JATKAR and N. V. SATHE, Bangalore.

The feeble paramagnetism of some oxides have been quantitatively explained on the basis of centrosymmetric model, electron number being determined from dielectric constant and coordination. The isoelectronic constants of Bhatnagar are thus given a theoretical basis.

11. Dipole moments of D.D.T., Fatty Acids triglycerides.

S. K. K. JATKAR and (Miss) S. B. KULKARNI, Bangalore.

The dielectric constants of D.D.T., p-nitrophenol, hydroxy-quinoline, capric, stearic and palmitic acid, tristearin and tripalmitin have been determined from the dielectric constants of the liquids and solids. The moments calculated by the new equation agree with those found by solution method. The results are discussed in relation to hydrogen bonding, free rotation and structure of the compounds.

12. Dielectric constant of quartz.

S. K. K. JATKAR and B. R. Y. IYENGAR, Bangalore.

The dielectric constant of crystal quartz and fused quartz has been determined by the plate method and also the mixture method. The value of the moment of SiO_2 , as calculated by applying the new equation has been found to be the same for fused quartz and crystal quartz.

13. Dielectric constant of liquid crystals.

S. K. K. JATKAR and B. R. Y. IYENGAR, Bangalore.

The electric moments in the solid and liquid states of p-azoxyanisole and p-azoxyphenetole have been determined from the dielectric constants, and indicate that there is the same free rotation in liquids and solids.

14. The dielectric constant of alcohols.

S. K. K. JATKAR and B. R. Y. IYENGAR, Bangalore.

The dielectric constants of water, alcohol, ethylene glycol and glycerine at low temperatures indicate restricted rotation due to hydrogen bonding so that the dipole moments are vectors up to melting point. At higher temperatures in the liquid the onset of rotation decreases the moment continuously. The homologous series of alcohols which show a constant moment in vapour state and in dilute solutions now show the expected increase as we go higher in the series.

15. Dielectric constants of proteins and amino acids.

S. K. K. JATKAR and B. R. Y. IYENGAR, Bangalore.

The dielectric increments of proteins and amino acids in water have been previously interpreted by empirical relationship with the chain length. The authors have applied the new equation to the solutions of amino acids poly-peptides, betaines, urea and its derivatives and have shown that the moments are about the same as empirically derived are vectors owing to hindered rotation and hydrogen bonding and are proportional to molecular weight.

16. The dielectric constants of hydrogen cyanide and organic halides in solid and liquid states.

S. K. K. JATKAR and B. R. Y. IYENGAR, Bangalore.

The phenomena of rotation in solid state has been studied in the case of *tert.* butyl chloride, *iso* butyl bromide, *iso* amyl bromide, dichloro *iso* butane, *tert.* amyl chloride and *iso* amyl chloride, methyl chloroform, di-chloropropane, stearic acid, ethyl benenate, tristearin and trilaurin from the study of dielectric constants at different temperatures. The results are in quantitative agreement with the new equation. The dielectric constants of *o*, *m* and *p*-chloro and *para* toluenes as well as of chloro and bromo cyclohexanes and other organic halides have been determined at various temperatures.

17. On the electrical conductivity of sulphur.

B. V. SRIKANTAN and C. K. SUNDARACHAR, Bangalore.

Sulphur, which possesses a lattice in which the units are S₈ molecules with a ring structure, is classed in the transition type between valence and molecular crystals. Its allotropy is very striking. Very little work on the resistivity of sulphur with change in temperature has been carried out, so far. The authors have studied by two different experimental methods, the variation in the conductivity of sulphur from 25°C. to 180°C. Both methods give concordant results which indicate that the electrical conductivity of sulphur increases slowly from 25°C. to 95°C. and then more rapidly till 118°C. Then it decreases slowly till 130°C is reached and again rises very rapidly. The temperatures at which these changes occur correspond to the m.p. and the transition temperatures in the allotropic behaviour of sulphur. The observed variation in conductivity on the basis of the present theory of solids is discussed.

Electronics and Ionics

18. Phenomena of change in colour of the high-frequency glow discharge.

N. R. TAWDE and G. K. MEHTA, Bombay.

During some investigations of the h.f. discharge in rarefied air excited by applying h.f. alternating potential to two external sleeve electrodes in a cylindrical discharge tube, it was observed that the colour of the glow showed a considerable change as the pressure in the discharge tube was reduced. This took place quite abruptly at a critical pressure keeping the frequency of oscillation and the excitation voltage constant. When the discharge was tried with other frequencies the value of the critical pressure was found to have changed. Excitation voltage also played a part in controlling this critical phenomenon. This shows that the change in colour is associated with all the three parameters i.e. pressure, frequency and excitation voltage. The change in colour may be interpreted as a consequence of some relative changes in the spectral intensities with the change in the velocity of the exciting electrons when the discharge conditions are changed. Explanation of these aspects from probe study of the h.f. discharge which is in progress in these laboratories is attempted in the paper.

19. Ionisation mechanism in the high frequency glow discharge.

N. R. TAWDE and G. K. MEHTA, Bombay.

The most fundamental as well as the most important process in any discharge is the process of ionisation by electron collision. The position of the h.f. glow discharge as far as the ionisation mechanism is concerned, is not yet well understood. Brassfield and many others have calculated the electric force in the h.f. discharge from the potential gradient the values found are too low to impart ionisable velocities to the electrons. From the results of our probe studies in the h.f. discharge we have come across the same difficulty. The values of the mean electron energies found in different cases lie much below the ionisation energy. A mechanism for ionisation to overcome the normal carrier losses by recombination and diffusion to the walls is absolutely essential for the maintenance of the discharge. There must be some fast moving electrons present in the glow discharge which are responsible for ionisation. Unfortunately the probe characteristics do not show any thing positive about the presence of these fast moving electrons. Further considerations of electrons gaining higher energies under simultaneous phase changes and elastic collisions are dealt with in the paper.

20. Thermal ionization of lithium and determination of specific charge of lithium ion.

B. N. SRIVASTAVA and A. S. BHATNAGAR, Allahabad.

The apparatus already employed by us in the earlier experiments has been used to investigate the thermal ionization of Lithium. The effusion currents have been measured with and without the magnetic field at various accelerating voltages for both positive and negative particles. The space charge theory developed in a previous paper for unipolar currents has been applied to the experimental data on the positive current under magnetic field. The value of e/m for the positive particle has been thereby determined. The magnetic field deflects the electrons and makes the beam effectively unipolar. An approximate theory has been developed for the case of a mixture of two types of particles of similar charge but different masses and the results have been tentatively applied to the negative currents. Calculations show that the unipolar theory is not applicable to the negative currents the reason being the presence of positively charged particles. The saturated currents are also measured and the energy of ionisation of Li determined with the help of the ionization formula. The ionization potential comes out to be 5.31 volts and the value of e/m for Li^+ is found to be 3.2×10^{18} e.s.u./gm in fair agreement with the known values.

21. Thermal ionization of calcium and determination of specific charge of Ca^+ .

A. S. BHATNAGAR, Allahabad.

The thermal ionization of calcium has been studied using the vacuum graphite furnace constructed by Saha and Tandon. The specific charge of Ca^+ has been determined by applying the space charge theory to positive currents under various potentials as explained in the paper on Lithium. The contribution of the terms $b(T)$ and $b'(T)$ for Calcium in the ionization formula tends to lower the effective ionization potential. The mean value of the energy of ionization is 136.9 K. Cals. The value of the specific charge of Ca^+ is 7.5×10^{18} e.s.u./gm.

22. Thermal ionization of aluminium and determination of the specific charge of Al^+ .

A. S. BHATNAGAR, Allahabad.

The thermal ionization of Aluminium has been studied employing the vacuum graphite furnace constructed by Saha and Tandon. The problem is experimentally more difficult than for other elements due to the low vapour pressure and large ionization potential of Aluminium, and has necessitated a little modification in the usual experimental arrangement. The mean value of the energy of ionization is found to be 135.9 K. Cals. which is in good agreement with the spectroscopically determined value within limits of experimental error.

Following the method developed in the paper on Lithium the e/m for Al^+ has also been determined by applying the space charge theory to unipolar positive currents produced by Al^+ ions. The value obtained is 1.22×10^{18} e.s.u./gm.

23. A study of the electronic current and its optical effects in a thyatron.

B. V. THOSAR, Nagpur.

The thyatron valve (Marconi G T I) contained Hg vapour and had a helical grid and a cylindrical anode. When used as a discharge device the grid is biased negatively. In this study, it was given a positive bias upto 10 volts and the anode potential E was increased gradually up to 11 volts, without allowing ionization current to flow. It is found that a greenish blue glow, consisting of Hg triplet 4046Å., 4358Å. and 5461Å., just appears on the inside of the anode when $E = 7.7$ volts in agreement with the excitation potential for the 3S_1 level. Using monochromatic filters it is seen that the yellow lines 5770 Å and 5790 Å appear not until $E = 8.8$ volts, corresponding to excitation to the 1D levels. The glow spreads inwards as E_A is increased. The inner edge of the glow is quite remarkably sharp, so that a travelling microscope could be used to measure its distance from cathode and anode.

The edge of the green glow corresponds to the position at which the accelerated electron has just enough energy to excite the line 5461 Å. i.e. 7.7 ev. Careful measurements for the position of the glow edge with reference to the electrodes have been made with E_g kept constant at various positive values upto 10 volts and increasing E_A in steps from 7 to 11 volts. At the same time readings for grid current and anode current were taken.

Measurements for the intensity of the green line in the glow were made with a polarization photometer for different values of E_g keeping E_A fixed. The intensity varied as the anode current. The total valve current does not exceed 8 m.a. and seems to be space-charge limited.

The results described in the paper provide a visual method of investigating the field distribution within a triode and are specially helpful in the difficult mathematical case of helical grid wires.

Heat and Thermodynamics

24. Thermo-mechanical effect in liquid He II.

D. V. GOGATE, Baroda.

One of the most important characteristics of liquid is the transfer of momentum that takes place in it in a direction opposite to that of the heat flow, near the λ -point. H. London has given a thermodynamical treatment of this effect and has shown that

$$\left(\frac{dp}{dt} \right)_{\max} < J\rho\phi$$

where ϕ is the entropy in calorie per gm., J is the mechanical equivalent of heat and $(dp/dt)_{\max}$ is the upper limit to the reaction pressure per degree.

In this paper an attempt is made to obtain an expression for the thermomechanical effect in liquid He II assuming the latter to be in a state of Bose-Einstein degeneracy.

The theoretical values of the reaction pressure per degree, as calculated from the derived formula are compared with the experimental values for different temperatures. The agreement between the theoretical and the experimental results appears to be fairly satisfactory.

25. Statistical thermodynamics and partitions of numbers.

F. C. AULUCK and D. S. KOTHARI, Delhi.

The paper deals with the connection between statistical thermodynamics and the partition functions $p(n)$, $p_k(n)$, $q(n)$, $q_k(n)$, $p(n,s)$, $p_k(n,s)$, $q(n,s)$, $q_k(n,s)$: $p(n)$ is the number of unrestricted partitions of n , $p_k(n)$ is the number of partitions of n into at the most k parts. $q(n)$ is the number of partitions of n when the summands are all different, and, $q_k(n)$ is the number of partitions of n into at the most k summands which are all different. The above partition functions are concerned with the partitioning of n into integers. If we consider the partitioning of n into S th powers of integers we define similarly $p(n,s)$, $p_k(n,s)$, $q(n,s)$, $q_k(n,s)$. The fundamental properties of the partition functions have been treated by Hardy and Ramanujan. (An interesting application of the Hardy-Ramanujan expression for $p(n)$, was made by Bohr and Kalckar to estimate the density of the energy levels in heavy nuclei).

The thermodynamical properties of an assembly consisting of a large number of similar systems are expressed in certain sum-over-states of the assembly. By contemplating suitable assemblies the partition functions, familiar in the theory of numbers, can be derived from statistical mechanics. Use is made of the theorem (Beth, Weisskopf)

which expresses the density of the energy levels in terms of the entropy of the assembly. The thermodynamical analogy allows us to generalise the partition functions for non-integral positive values of S .

Light

26. A physical theory of the Light Effect in gases under electrical discharge S. S. JOSHI, Benares.

It has been observed that the discharge current passing through an ozoniser type of vessel reduces by an amount Δi , when the vessel is subjected to the influence of an external source of light. Detailed investigations into the conditions under which this effect can be produced, have been made. The nature of this effect has been studied by spectrographic methods. All the predominant features of this Light Effect are now sought to be explained on the basis of a physical theory.

In this theory it is assumed that (a) under discharge an activated layer is formed on the electrodes and it is in dynamical equilibrium with the gas phase; (b) as a primary step photo-electric emission occurs from this active layer and (c) that the photo-electrons thus emitted are captured by the highly electro-negative elements present in the vessel to produce negative ions.

These negative ions account for the effect. Further they produce an opposing electrostatic field which finally cuts off the photo-electric emission. On shutting out the incident light these electrons producing the electrostatic field, return to the electrodes and thus produce an instantaneous reverse effect.

On the basis of this theory all the prominent features of the effect are explained easily. It also accounts for a number of recondite features.

27. Influence of nitrogen on the *Joshi-Effect* in chlorine under electrical discharge.

K. V. RAO and P. K. NARAYANASWAMY, Benares.

In view of the observations of Joshi and Deo (*Nature*, 1944, 154, 434) who found that the above phenomenon could be made as large as 93% current decrease under light, by mere regulation of pressure at a constant applied potential, it was of interest to find out the influence of a non-reactive gas like nitrogen in increasing the pressure. The results showed that at a given potential and chlorine pressure, on admitting nitrogen, there is marked increase in the discharge current and not light-effect. The light-effect expressed as the percentage of the current in dark, however, diminishes. The results were strikingly different, when the two ozonisers connected in parallel and containing either of the above two gases, were excited and the *light-effect in the combined current observed*. Both these quantities increased markedly when the above gases were allowed to intermix.

28. Influence of capacitative reactance on the *Joshi-Effect* in chlorine and bromine vapor under electrical discharge.

P. K. NARAYANASWAMY, Benares.

It was observed by Prof. Joshi that the value of a capacity in the path of the discharge current determines appreciably the magnitude of the corresponding *light-effect*, and that this is attributable to the circumstance that the high frequencies produced under discharge represent the seat of this phenomenon. The role of an external capacity has been investigated for either of the above gases over a range of 2.5 kV applied to the discharge tube. As is to be anticipated on general grounds, it was observed that the conductivity i due to a given applied potential diminishes as the capacity added serially to the discharge tube, is increased; the corresponding percentage *light-effect*, i. e.

$\frac{\Delta i}{i} \times 100$ however, increases. Results were opposite when the external capacity,

varied over wide range, was introduced in parallel with the discharge tube. It was now observed that the conductivity i at the same applied potential as in the previous series, increased. The corresponding net as well as the percentage *light-effect*, however, diminished markedly.

29. Influence of resistive impedance on *Joshi-Effect* in chlorine and other gases under electrical discharge.

P. K. NARAYANASWAMY, Benares.

Arising out of the observations of Prof. Joshi that Δi the magnitude of the new *Light-effect* in gases activated by electrical discharge depends appreciably on the nature

of the current indicator (Joshi, Pres. Add., *Chem. Sec.*, Ind. Sci. Cong. 1943; also *Curr. Sci.* 1945, 14, 67-68) and especially the general finding that R , which may be a stabilising or an external resistance, suppresses the relative *light-effect* (Joshi, *Proc. Ind. Acad. Sci.* 1945, 22, 4), the present work was undertaken to investigate the general validity of the above deduction.

It is found, that as long as the conductivity i is due to ionisation by collision under external fields, R always decreases i . The above influence is sensibly larger in the low tension than in the high tension part of the circuit. This inhibition of i due to R at a given exciting potential depends markedly on the gas pressure. Thus, for example, it was interesting to observe that in air, Nitrogen, Hydrogen and Oxygen the inhibitive effect of R was most pronounced in the range 50-60 mm. Hg, in the potential range 2 to 4 kV at 50 cycles frequency.

The above results also applied to Chlorine and Bromine vapour. In the former, due to $R=1,000$ ohms, i decreased by about 10 per cent. The corresponding *light-effect* with and without R was 36 and 32 per cent respectively. It may be emphasized that the exciting potential is not sensibly altered by adding R .

30. *Joshi-Effect* from the standpoint of Kramers dispersion formula.

B. LAHIRY and P. DASGUPTA, Benares.

In the present work on the above phenomenon observed, in chlorine, iodine vapour and air, two series, (a) and (b), of observations were taken in each case :

(a) Under H. F. oscillations (5 to 10 megacycles) from an H.F. oscillator, and irradiated by a 200 watt bulb, and a Hg. vapour lamp respectively ;

(b) Under high voltages varied in the range 5 to 8 kV at 50 cycles frequency from a transformer and irradiated by the above mentioned light-sources.

It has been found that there is no diminution in conductivity in (a), that is, when the current is only of the dielectric or displacement type ; whereas, the full *light-effect* is observed in (b) under corresponding conditions. These results are incompatible with Prasad's theory (*Nature*, 155, 365, 1945) for the *Joshi-effect*, viz., that it is due to diminution of dielectric current. The fact that the *Joshi-effect* is not produced below the 'threshold potential' characteristic of the gas, the pressure and other operative conditions shows that the phenomenon is obtained only when there is ionisation by collision.

31. Distribution of the *Joshi-Effect* between the total (low tension) and the h.f. conductive under electrical discharge.

P. DASGUPTA, Benares.

From the oscillograms of discharge current (Joshi, *Nature*, 1944, 154, 147) and especially the use of wave-filters (Joshi, *Curr. Sci.*, 1945, 14, 67) it appears that the chief seat of this phenomenon lies in the H.F. components. The generality of this deduction has been investigated in considerable detail, under a variety of conditions in chlorine and air, at their respective optimum pressures, when subjected to silent discharge in a Siemens' tube. The discharge current i was measured with a vacuo-junction between the low tension electrode and the earth. Following Joshi's procedure (*Nature*, loc. cit.) the current picked up by an aerial near the ozoniser served to indicate the H.F. conductivity. This conductivity i aerial and the total low tension current i decreased markedly on irradiating the ozoniser. It was in general found that the relative *light-effect* i.e. percentage current decrease under light, was appreciably greater in aerial current i.e. in the H.F. region than in the rest of the current.

As is to be anticipated on general grounds when aerials of different capacities were used, the percentage *light-effect* was sensibly the same when the aerial current was the same, although the exciting potentials were appreciably different.

32. Applicability of the *Joshi-Effect* in a heterodyne type 'Mixer'.

G. S. TIWARI, Benares.

Joshi's results using H.F. and L.F. filters (Joshi, *Curr. Sci.*, 1945, 14, 67) and cathode ray oscillograph (Joshi *Nature*, 1944, 154, 147; Joshi, *Curr. Sci.*, 1944, 13, 253) having shown the existence of a large number of frequencies of various strengths, besides the supply frequency, in the discharge current; and furthermore, that the *light-effect* consists predominantly in a suppression of the amplitudes of those frequencies (Joshi, loc. cit.) the present work was carried out in order to investigate the possibility of heterodyning these frequencies in the discharge with the output of another H.F. oscillator as in the superheterodyne sets.

A moderate size frame aerial was placed near the chlorine tube and the discharge produced as usual by A. C. excitation. The aerial current both in dark and when the discharge tube was irradiated, were determined by a sensitive D.C. galvanometer connected to a Cambridge vacuo-junction. Alternating currents of frequencies which could be varied in the range 5 to 10 megacycles per second, were generated by a Hartley type valve oscillator; these were allowed to 'mix' with the aerial current and the mixed current measured in dark and under light. In one case, for example, when the oscillator current was 5 units and the aerial current in dark 3.46 units, their mixed value was only 6.0 units. It was found that Δi , the decrease in the aerial current, alone was 1.07 units corresponding to about 31% *light-effect*; when mixed electrically with the oscillator current, Δi was 0.53 unit, that is, a 9% *light-effect* only. This is typical of series of results obtained for different values of the aerial and oscillator current at various frequencies. These data indicate the utilisability of the light-effect phenomenon in a new type of 'mixer' circuits.

33. Production of the *Joshi-Effect* in aerial currents observed at various distances from the discharge tube.

G. S. TIWARI, Benares.

It was observed by Prof. Joshi (*B.H.U. Journ.*, 1943, 8, 103, also *Nature*, 1944, 154, 147) that an ozoniser-like vessel behaves like a transmitter especially markedly when the exciting potential, frequency and the gas pressure are adjusted for the production of the maximum *light-effect*; that is, the largest decrease under light of the corresponding conductivity. The possible use of this phenomenon for signalling at a distance was suggested by Prof. Joshi. In these experiments currents picked up by a moderate size aerial were determined by means of a vacuo-junction over a distance of about 15 metres from the discharge tube. At a constant applied potential this aerial current diminished rapidly in the neighbourhood and markedly slowly at larger distances from the chlorine tube. The *light-effect* was appreciable all over the range of distances mentioned above. Its variation with distance was similar to that of the aerial current and could be observed directly either as a current decrease or/and decrease in the volume of the sound from a loud speaker.

34. Studies of the *Joshi-Effect* at various frequencies in the discharge through chlorine.

G. S. TIWARI, Benares.

The role of the high frequency components in the discharge current i was emphasized by Prof. Joshi as an important determinant under given conditions, of the magnitude of this new phenomenon, namely Δi a decrease of the conductivity i by irradiation (Joshi, Pres. Address, Chem. Sec. Indian Sci. Cong., 1943). Joshi had also pointed out that these higher frequencies in i represented both the audio and radio ranges (Joshi, *Nature*, 1944, 154, 147; Joshi, *Curr. Sci.*, 1944, 13, 253). It was of interest, therefore, to investigate Δi at various frequencies produced under the discharge.

The electrical discharge was produced in the annular space of a Siemens' ozoniser filled with pure chlorine by applying a suitable alternating potential across it. A moderate size frame aerial was kept near the ozoniser and was fed into a battery-operated four valve Phillip set. The set was of reaction type and had different tuning coils of the ranges between 10-2400 metres, so that any desired frequency could be tuned in by plugging in a suitable coil. A horn type loud-speaker was connected to the set for receiving the signals. Following the procedure of Joshi (*Curr. Sci.*, 1944, 13, 253), the *light-effect* in the present investigation was first observed from the decrease of the volume of the sound from the loud speaker when the discharge tube was irradiated, and also by a current indicator. First, an adjustment for maximum *light-effect* as judged with the loudspeaker connected in the output stage of the power amplifier valve of the set was made; the loudspeaker was then replaced by the current indicator and i_D , the current in the dark and i_L , that under irradiation were measured at a number of wave-bands (10-30, 15-58, 45-160, 85-300, 230-860 and 670 to 2400 metres). In the first series a milliammeter and then a microammeter after reducing the current of the set to zero were used and the corresponding currents observed.

Finally, the discharge current under dark in all the ranges was kept constant and Δi , the decrease in i_D , was determined on irradiating the discharge tube.

From the results obtained it was found that whilst i_D and Δi , the net *light-effect*, increase with the wavelength, the percentage *light-effect* decreases continuously. If, however, i_D at various wavelengths is kept constant, both Δi and percentages *light-*

effect $\frac{\Delta i \times 100}{i_D}$ diminish by increasing the wavelength.

35. Comparative studies of the *Joshi-Effect* with a diode and other a. c. detectors

B. N. PRASAD, Benares.

The apparent variability of the magnitude of this phenomenon, viz., Δi an instantaneous and reversible decrease of the conductivity in chlorine and a number of other gases has been observed by Joshi (Presi. Address, Chem. Sec., Indian Sci. Cong. 1943; *Curr. Sci.*, 1945, 14, 35). The present work was undertaken in order to investigate this light-effect with a vacuo-junction and a 6H6 double Diode used as a half wave rectifier. The discharge current obtained from a chlorine tube adjusted to optimum conditions in respect of the light-effect Δi , was allowed to flow through the primary of a 1 : 3 step-up, iron core, transformer. Its secondaries were connected to the plates and the cathodes through a D.C. galvanometer with a shunt in the appropriate range. It was remarkable to observe in these experiments that the light-effect was high as 81% of the current in dark. Results for the light-effect was under identical conditions of excitation observed with a vacuo-junction were similar, but sensibly smaller in magnitude.

In the next series of results, the input to the Diode was tapped from a non-inductive and non-capacitative resistance R , introduced between the low tension electrode and the earth. In agreement with Joshi's results, it was observed that the percentage light-effect was greatly reduced. This influence of the resistance R in suppressing the light-effect was also brought out when the currents were measured with a vacuo-junction connected to a galvanometer. It was interesting to observe that this influence of R was markedly uniform under all conditions of excitation and also free from apparently anomalous results, observed when this phenomenon is studied using a triode and a pentode as A.C. detectors, at large R and exciting potentials.

36. Certain anomalous results in the *Joshi-Effect* observed with a triode.

B. N. PRASAD, Benares.

During studies of the phenomenon viz., Δi an instantaneous and reversible diminution on irradiation of the conductivity in chlorine and other gases, it was observed by Prof. Joshi that with all the systems investigated so far, Δi , as indicated by a vacuo-junction, had been either nil or negative; the metal oxide type rectifiers showed, however in some cases the opposite, that is, a positive effect (Presi. Add. Chem. Sec., Indian Sci. Cong., 1943). The present work was undertaken to investigate this phenomenon using various thermionic valves as current detectors.

With a triode 30, for example, three series of results were obtained. When the discharge current from the chlorine tube was allowed to flow through a 1 : 3 step up iron core transformer whose secondaries fed the triode, it was observed that on irradiation the *Joshi-effect* was 93% and more. When, however, the triode was connected across a pure resistance R between earth and low tension electrode of the chlorine tube, the *Joshi-effect* was higher both in the grid and plate circuits, for moderate values of R . At a given V , the exciting potential on the chlorine tube and large R , and also given R and large V , it was remarkable to observe that the plate current showed upto 31% positive *Joshi-effect* on irradiation, instead of decreasing as usual. The results were similar using the anode bend, the grid-leak, and the push-pull anode bend rectification. It must be emphasised that in all cases observed, the *Joshi-effect* was normal in the grid circuit, that is to say, the grid current always decreased under irradiation.

The positive effect is attributed to the special role of high frequencies produced under the discharge, and which were shown by Joshi to be chiefly responsible for the occurrence of this phenomenon.

37. Observation of *Joshi-Effect* with a 6J7 pentode.

B. N. PRASAD, Benares.

During the studies of the above phenomenon using a R. C. A. 30 triode, it was suspected that secondary emission within the valve was partly responsible for some of the apparently anomalous results especially at large inputs (*vide infra*). This factor is practically negligible with a pentode; 6J7 was used. This served remarkably well over a wide range of operating conditions. Joshi and Deo (*Nature*, 1944, 153, 434) using a Cambridge vacuo-junction observed a *light-effect* as high as 93% by adjustment of gas pressure.

I have now found that with the above pentode starting with an arbitrary chlorine pressure, viz., 260 mm. and applied potential about 4kV, at a 50 cycles frequency, a reproducible *light-effect* of 96% is observed. In marked contrast with the above triode, the grid current and therefore, any changes therein due to the *light-effect*, were negligibly

small. At large inputs, however, as with the triode the *Joshi-Effect* changes sign ; i.e. a large increase of current under light, in fact larger than that with a triode is observed. This, however, cannot be attributed to secondary emission in the valve ; but rather as suggested by Prof. Joshi to the behaviour, such as for example the saturation limits, of the high frequencies produced under this discharge.

38. *Joshi-Effect* in bromine.

K. V. RAO, Benares

The present paper deals with the influence of frequency and intensity of the incident radiation on the *light-effect* in bromine. An ozoniser sealed with bromine at the optimum pressure is enclosed in a box with an opening on one side which can be screened. It is found that both the not *light-effect* as well as the percentage *light-effect* are in the order unfiltered white >violet >red ; with the green filter no *light-effect* is observed.

The intensity of the incident radiation is varied by keeping the light source at different distances from the ozoniser ; the relative light intensities are measured by a "Kipp's 37" thermopile. Despite the enhanced intensity in the red, in light due to a filament lamp, it is interesting to observe that the *light-effect* is almost negligible in this region. The magnitude of *light-effect* increases with increasing frequency and intensity and the former appears to be the more important factor.

39. *Joshi-Effect* in iodine.

K. V. RAO, Benares.

Results of experiments carried out with a view to determine the exact conditions under which iodine shows the *light-effect* have been recorded. The experimental arrangement and procedure is similar to that adopted by Joshi and Kane (*Proc. Ind. Sci. Cong.*, 1942, Part III, p. 61). Contrary to the reports of Joshi *et al.*, no *light-effect* is observed in iodine under almost identical conditions of the experiment. But when the wall of the ozoniser are coated with iodine, potassium iodide and potassium chloride (taken in aqueous solution and dried up) both the not *light-effect*, Δi , and the percentage *light-effect*, % Δi , are prominent being 2.4 and 38 respectively (for a current value of 6.3 units). Both Δi and % Δi diminish rapidly with time as observed by Joshi and Murthy (*Proc. Ind. Sci. Cong.*, 1942, Part III, p. 64). A mixture of air and iodine or chlorine and iodine also does not show any *light-effect*, presumably, due to the interplay of a variety of surface and photo-effects. In all these cases, however, the familiar ageing phenomenon, observed by the earlier workers, is found to be prominent.

40. Budde Effect in halogens : mechanism of the phenomenon.

P. G. DEO, Benares.

It was emphasized by Joshi (*Proc. Ind. Sci. Cong.*, Presidential Address, *Chem. Soc.*, 1943) that there is apparently some considerable analogy between the new *light-effect* and Budde effect. A review has therefore, been made of the experimental results and also the mechanisms proposed by different investigators for the production of this phenomenon. Influence on the magnitude of the Budde effect, of the gas pressure, the temperature, the intensity and the frequency of irradiation, and of extraneous factors such as moisture, nature of the walls etc. has been discussed. General consideration of these results, suggests that primary photo-dissociation of a halogen molecule followed by a temperature rise due to subsequent recombination of the dissociation products through triple collisions, based on the theories of Franck (*Trans. Fara. Soc.*, 1926, 21, 536), and Born and Franck (*Z. Physik*, 1925, 31, 411), is the probable mechanism of this phenomenon.

41. Conductivity of air under electrical discharge between metallic electrodes and irradiation in the visible, ultra-Violet and X-rays, from the standpoint of the Joshi-Effect.

D. P. GOYAL, Benares.

The present work was undertaken in order to elucidate the apparent contrariety between the *Joshi-Effect*, viz., an instantaneous and reversible current decrease produced under even visible light, and the classical photo-electric effect. Exhaustive series of observations were made using (a) metallic points and (b) aluminium and brass spheres to serve as electrodes ; those were excited by V alternating potentials in the range 2 to 5 kV and 50 cycles frequency. The inter-electrode distance was also varied. Very great difficulties were experienced due to fluctuations of the discharge current, despite a large stabilising resistance of at least 50,000 Ω and a sensibly constant V. It was

most pronounced between point electrodes; this is attributed, in part to space charge effect and especially the action of the discharge on the electrode extremities. The procedure in a given set of observations was to observe at regular intervals (10 seconds) the discharge current for a definite period (3 minutes), in dark; the series was then repeated under irradiation under identical conditions. Excluding those periods when the current fluctuations were abnormal, a review of 30 sets of well over 1000 observations showed that the current is slightly reduced under the visible light. Similar results under X-rays showed, however, an increase of the current.

The above fluctuations were much less with spherical electrodes. A scrutiny of about 1,000 results reveals that any current decrease due to light is comparatively less frequent. Results under the Ultra-Violet and the X-rays showed a general current increase. These findings are in agreement with the view of Prof. Joshi (*Curr. Sci.*, 1945, 14, 175) that the above light-effect requires an extended dielectric surface as a necessary condition for its production.

42. Studies in Lange type photo-cell.

D. P. GOYAL, Benares.

Arising out of work in these Laboratories on the influence of light on the conductivity of chlorine and some other gases, and especially the importance of the solid-gas interphase in this *Light-Effect* as emphasized by Joshi (*Curr. Sci.*, 1945, 14, 175) the present work on the behaviour under light of Cu-Cu₂O electrode was undertaken. From numerous trials using various methods of preparation, cooling of pure copper heated in air to about 1000°C gave quite sensitive surfaces. Results were, however, better when heated copper was quenched suddenly in cold water. It was remarkable to observe that apparently good deposits of cuprous oxide produced by external chemical depositions produced but negligibly insensitive surfaces.

The influence of the following factors was investigated on the light-sensitivity, defined as the increase of current over that in dark: (i) nature and concentration of the external cell electrolyte, (ii) nature of the cuprous oxide deposit and (iii) nature of irradiation.

Under (i) it was observed that the light sensitivity increased in the order sodium chloride < lead nitrate < potassium nitrate. It was interesting to find that a large increase in the electrolyte concentration diminished the light-sensitivity. (ii) the light-sensitivity increased by increasing the cuprous oxide deposited area on the electrode exposed to light as also by improving the uniformity of the deposit. (iii) the light-sensitivity appears to be greater in the more refrangible portion of the (visible) spectrum. It was remarkable, however, that no response was detected under irradiation with X-rays. As is to be expected from general theory the light-sensitivity is proportional to the corresponding intensity. The last quantity being varied either by varying the distance between the light source and the cell and also from $\cos^2 \lambda$ where λ is the inter-axis setting in a polaroid-pair, used as an intensity-variometer (*vide*, P. G. Deo, *Proc. Ind. Sc., Cong.*, 1944, Part III, p. 27).

43. Influence of X-rays on the after glow of active nitrogen

K. V. RAO and NARAYANA SWAMY, BENARES

The periods of decay of the after glow of active nitrogen (observed in an uncoated glass bulb are noted) with and without exposing the after glow to a beam of X-rays. The duration of the decay of the glow is found to be identical in the two cases. It is therefore, likely that the processes leading to ionization and glow production are quite independent as held by Lord Rayleigh.

44. Optic moments of organic molecules

M. RAMANADHAM, Madras.

Optic moments of organic molecules like naphthalene, anthracene, phenanthrene, diphenyl and dibenzyl are calculated from their principal refractive indices and they have been used to account for quantitatively, the observed refractive index, Cotton Mouton constant and depolarisation of scattered light of the substances either in the liquid state, or in solution or in the gaseous state.

Meteorology

45. Microseisms and disturbed Weather.

S. K. PRAMANIK, P. K. SENGUPTA and K. C. CHAKRAVARTY, Poona.

Banerji, Lee, Ramirez and some other authors have studied the relationship between microseisms and disturbed weather. It is found that the seismograms of Alipore Meteorological Office give valuable information about disturbed weather at sea and in some cases, when ships observations are not available, they give definite indication of disturbed weather out at sea, not available from synoptic charts. A detailed examination of the Alipore seismograms and the synoptic charts for 8 years were undertaken to study microseisms from the point of view of day to day forecasting. These main conclusions are as follows:—

- (A) Microseisms are of 3 types which can be easily distinguished from one another:
 - (i) Monsoon type—uniform and steady vibrations—period 3 to 7 seconds.
 - (ii) Storm type—the amplitudes are not uniform and regular but increase and decrease—forming groupings of large and small amplitudes—periods 3 to 6 seconds.
 - (iii) Gusty wind type—series of uneven bulges with a sort of period of 1 minute or so.
- (B) Strong surface winds, squalls or thundersqualls over land unassociated with storms and depressions from the sea do not generally cause any appreciable microseisms.
- (C) Depressions and storms of land origin, over land, do not produce any storm microseisms, but if they cause a strengthening of the monsoon over the sea, monsoon microseisms may appear.
- (D) Advance of monsoon in Arabian Sea does not produce any microseisms. Advance and strengthening of monsoon in the Bay (even in the south Bay) often produces monsoon microseisms.
- (E) Often in the initial stages of development of a disturbance in the Bay of Bengal monsoon microseisms first appear and later give place to storm microseisms.
- (F) The more intense a disturbance and the nearer it is, the larger are the microseisms generally.
- (G) Depressions and storms in the Bay generally give storm microseisms.
- (H) Once the storm microseisms have appeared they do not vanish until the disturbance fills up or it crosses coast and moves away.
- (I) Storm microseisms sometimes appear before the swell and strong wind of a disturbance reach the coast.
- (J) Storms in the Bay of Bengal do not often produce any microseisms at Bombay and similarly storms in Arabian Sea do not often produce any microseisms at Calcutta.
- (K) The gusty wind type microseisms are caused by the tilting of the seismograph pillar.

46. Computation of winds in the atmosphere.

S. K. PRAMANIK, Poona.

During cloudy weather in India, a rough idea only of the winds aloft could be obtained from the surface isobaric charts and observations of cloud movements. Radio Sonda and aeroplane ascents are now being taken from a net work of stations in and around India giving pressures and temperatures at different levels. One can calculate the geosotropic winds from the isobaric charts for different levels prepared from these data. The geosotropic wind, however, differs appreciably from the gradient wind, which gives a satisfactory approximation to the true wind, even in higher latitudes. It is necessary to obtain the corrections to be applied to the geosotropic wind to obtain the gradient wind in Indian latitudes. The percentage corrections were calculated for 10, 20 and 30 degrees latitudes for different ranges of velocities and curvatures. It is seen that

- (i) The geosotropic wind generally gives an unsatisfactory approximation to the gradient wind,
- (ii) The percentage corrections increase with increasing curvature and with the velocity of the geosotropic wind and decrease with increasing latitudes,
- (iii) The percentage correction for anticyclonic motion is more than that for cyclonic motion for the same latitude, velocity of geosotropic wind and curvature,
- (iv) Anticyclonic motion is not possible when the convection is more than 50 per cent.

47. Evidence for the existence of the "Emission layer" in the atmosphere.

R. ANANTHAKRISHNAN, Poona.

The theory of radiative equilibrium demands that on the average the total amount of energy absorbed by the earth and its atmosphere in the form of short-wave solar radiation should be exactly equal to the total amount of energy given back to space in the form of long-wave heat radiation. From a study of the absorbing and radiating properties of the atmosphere, F. Albrecht arrived at the fundamental result that the major contribution to the long-wave heat radiation into outer space originates from a layer of some three to four kilometres thickness in the upper troposphere which he designated as the "Emission Layer". The emission layer is thus a portion of the upper atmosphere which is continually cooling due to radiative loss of heat. The height of the emission layer is a function of the water vapour content of the atmosphere; it is more when the atmosphere is hot and humid and less when the atmosphere is cold and dry.

The author has made a detailed study of the thermal structure of the atmosphere over Agra based on the results of sounding balloon ascents over a period of ten years. A number of interesting features find a ready explanation on the assumption that the emission layer over Agra is located approximately between 11 and 14 gkms in the monsoon months and between 8 and 11 gkms during the remaining months—an assumption quite in conformity with Albrecht's work. The observed seasonal variations in the thermal structure of the atmosphere over Agra thus lend strong evidence for the existence of the emission layer in the atmosphere and the variation of its altitude depending upon the moisture content of the atmosphere.

48. An electronic integrating solarigraph.

A. U. MOMIN, Poona.

A number of instruments are available for the measurement of both the duration as well as the intensity of sunshine; but for obtaining the value of the total amount of radiation received, it becomes necessary to integrate the intensity curves of the records given by these solarigraphs. This is a laborious process even when performed with mechanical means like the planimeter etc. The need for a solarigraph which can automatically integrate the incoming solar radiation has, therefore, been felt for some time.

The paper describes an instrument of this type which makes use of an electronic integrating and counting circuit and registers the data on an electromagnetic counting mechanism. The operating principle of the instrument is briefly as follows:—

The current from a photocell (caesium oxide) is allowed to charge a condenser to a critical voltage determined by the ionising potential of a neon tube connected across the condenser. When this voltage is reached the neon tube becomes conducting and discharges the condenser until its voltage reaches the extinguishing potential of the neon tube. Then the condenser starts charging up again and the cycle is repeated at a frequency which is dependent on the intensity of the sunlight falling on the photocell. The glow discharge of the neon tube supplies a voltage impulse to the counting circuit which registers a count on a telephone message register. The number of counts registered by the instrument in a given time multiplied by a factor determined by comparing the instrument with an Angstrom Pyrheliometer at once gives the total amount of solar radiation received by a unit area in gramme calories.

A novel type of trigger circuit used in the counting section of the instrument has also been described. The paper also gives a brief survey of the earlier work on the subject.

49. Temperature fluctuations in the air layers near the ground.

A. U. MOMIN and R. Y. MOKASHI, Poona.

The intense lapse-rates produced in the air layers very close to the ground on clear days give rise to the well-known 'shimmering layer'. L.A. Ramdas has shown that this layer consists of filaments of warm ascending air and compensating currents of cool descending air; and any given point in this layer would undergo a fluctuation in temperature as it comes under the influence of hot and cold air currents alternately.

The paper describes some measurement of these short period temperature fluctuations made with the help of very fine constantan-copper thermocouples and a Moll galvanometer. The observations were made on selected clear days at different times of day at the surface of the ground, 1 cm, 10 cm, 20 cm, 1 metre, 5 metres and 10 metres above ground. From the records it is clear that the region of most violent fluctuations of temperature corresponds to the region of greatest lapse-rates where the velocities of the up

and down movements are maximum. Measurements made with conditions of temperature inversion shows an almost complete absence of violent fluctuations at all the heights up to 10 metres.

Nuclear Physics

50. The radioactivity of the neutron.

C.-K. SUNDARACHAR, Bangalore.

The heavier mass of the neutron as compared with that of the proton makes it probable that the neutron is beta-radioactive with a half life of about three hours. As a possible search of this property of the neutron, K.C.Wang (*Nature* vol. 155 P.574, 1945) suggests a spectroscopic test for hydrogen in a mass of liquid heavy hydrogen, after irradiation by a beam of slow neutrons. Some evidence for the radioactivity of the neutron is forthcoming in the experimental investigation of the elastic scattering of neutrons in deuterium gas, by J.F.Streib and the author. (C.K.Sundarachar and J.F. Streib. *Nature*. 149. 51. 1942. ; Jour Mys. Univ. 3. 55. 1942.). The neutron beam was produced by 4 micro-amperes of deuterons bombarding beryllium metal and accelerated by the one million volt cascade transformer in the California Institute of Technology. A linear amplifier feeding a Duddell type oscillograph measured the energy of the recoil deuterons in a brass ionisation chamber filled with heavy hydrogen at 7 atmospheres pressure. It was noticed that about one in twenty of the recoil pulses corresponded to energies much in excess of the maximum energy group of neutrons released in the Be-D nuclear reaction with the 600 kilo-volt accelerating voltage used in the experiments.(Bonner and Brubaker. *Phy.Rev.* 50. 308. 1938.). The fact that these pulses were not noticed, when the neutron production was stopped, rules out the possibility that they are of cosmic ray origin. The high energy pulses may, therefore, correspond to the decay neutrons traversing the ionisation chamber, after getting scattered by the one foot thick concrete walls of the small enclosure, in which the detection apparatus was located.

Properties of Matter

51. A new method for the determination of the average diameter of textile fibres, filaments, fine wires, etc.

NAZIR AHMAD and R. L. N. IYENGER, Bombay.

The fineness of the cotton fibre, as expressed by its diameter is an important character, especially in the case of the long staple cottons. A new method has been developed for determining quickly and accurately the mean diameter of a large number of fibres, which is applicable not only to cotton fibres but to other textile fibres, filaments, fine wires, etc.

In this method a uniform beam of light passing through a rectangular slit of length l falls on a photoelectric cell producing a current I_1 . A parallel bundle of n opaque fibres, stretched with as little overlapping as possible is interposed between the slit and the cell. The photoelectric current is reduced to I_2 . It can be easily shown that the diameter d of the fibre is given by

$$d = \frac{1}{n} \frac{I_1 - I_2}{I_2}$$

The number, n , can be counted either with the naked eye or under a low-power microscope.

Using this apparatus the average diameter of many textile fibres covering a wide range of values have been measured. Their diameters were also determined microscopically for purposes of comparison. In all cases, ranging from diameters of 12 to 120 the values obtained by the photoelectric method were not significantly different from those microscopically obtained.

52. On the velocity of propagation of gravitational waves within matter.

G. SURYAN, Madras.

The investigations of Einstein and Eddington on the propagation of Gravitational disturbances show the possibility of gravitational waves in space. They travel with the velocity of light and can be classified into three classes (1) Longitudinal Longitudinal

(2) Transverse transverse and (3) Longitudinal-Transverse. In this paper the investigation is extended to gravitational waves within a thin distribution of matter. That waves should exist requires their velocity to be the fundamental velocity itself. Further it follows that the classification of the waves in to three types is not possible, the L-L and T-T waves being not independent of each other.

53. Hygroscopic properties of plant material.

L. D. MAHAJAN, Patiala.

The hygroscopic properties of plant-material has been studied. It has been observed that the material of the plants, produced by crushing and dried, in powdered form, is hygroscopic in character. It has high power of absorption of moisture from the moist air and behaves like soil. It is a better absorber of moisture than the sandy, loamy or clayey soils.

The material produced from the young plants by crushing them is better absorber than that produced from the grown up and older plants. The powder of the seasoned wood is of little use for this purpose.

Such material if added in soils increases their absorption power and may possibly decrease the frequency of irrigating the land.

54. Side-lights on spherical soap bubbles.

B. A. KRISHNASWAMY RAO, B. S. SRIKANTIA and L. SIBAIYA, Tumkar

Soap bubbles present many interesting lines of investigation. Sibaiya and later Venkatesh used the time of collapse of a soap bubble for estimating the viscosity of a gas, which was forced out of a long glass tube during the gradual collapse of the bubble.

Such other uses for the soap bubble can be further investigated. It is, for instance, shown that a falling soap bubble attains a terminal velocity (v) and the thickness (t) of the bubble can be estimated from

$$t = \frac{3\eta v}{2r\rho g}$$

where η is the viscosity of air, r the radius of the bubble and ρ the density of the soap solution.

Again, it is usually observed that spherical soap bubbles rebound from water surfaces. By finding the small heights from which they fall and the smaller heights to which they rebound the coefficient of restitution is estimated (~ 0.42). Besides this, the time of disappearance of the floating bubble by breakage is a function of its size and the nature of the liquid surface, and is of the order of 3.5 secs. in the case of bubbles of 7 cms. diameter on water. The time is increased when soap solution replaces the water.

When a soap film is formed at the end of a conical funnel, the film gradually moves back and disappears. If a slight excess of pressure is exerted the equilibrium position of the bubble can be used for estimating the pressure excess. Thus the spherical segment of the film in the funnel can be used as a sensitive manometer for estimating small pressure excesses.

55. On the variation of the electrical constants of soil, with the frequency of the measuring field.

S. R. KHASTGIR, Dacca.

The total electrical conductivity of any soil medium at any frequency consists of (1) d.c. electrical conductivity, (2) electrical conductivity due to displacement currents and (3) that due to orientation of polar molecules in the electrical field. The electrical conductivity due to displacement currents in the soil can be shown to be proportional to the frequency of the measuring field and that due to the orientation of the polar molecules can be obtained from Debye's formula. In the audio-frequency range the contribution of the displacement currents to the electrical conductivity is much more pronounced than that due to the orientation of the soil molecules, so that in this range the electrical conductivity is virtually of the form : $\sigma = \sigma_0 + k_1 f$, where σ_0 = d.c. electrical conductivity and k , a constant. This has been substantiated by all workers employing audio-frequency currents.

In the radio-frequency range, the Debye-effect is considerable. Usually for a soil, the product of relaxation time and the angular frequency is very much less than unity; under such condition it follows from Debye's formula that the electrical conductivity is proportional to the square of the frequency (i.e. $\sigma = k_1 f^2$, k_1 being a constant). Considering also the skin effect which is no longer a small quantity in the high frequency range, the total electrical conductivity of soil can then be represented by

$$\sigma = \frac{k_0}{\sqrt{f}} + k_1 f + k_2 f^2 \quad \text{where } k_0 \text{ involves the d.c. electrical conductivity.}$$

For extremely high packing of the soil, in the radio-frequency range, the skin effect is most prominent. The electrical conductivity would therefore decrease with the increase of frequency, whereas, for low packing, the Debye-effect plays an important part. The electrical conductivity of soil for low packing is thus expected to increase with frequency. The variation of the dielectric constant with frequency should be attributed solely to the orientation of the polar molecules in the soil medium and is expected to follow Debye's formula.

The experiments with Amalendu Banerjee with different soils packed to different extents (the maximum packing being 4500 lbs. per sq. in.) have substantiated the above theoretical conclusions.

56. Particle size problems of industry

L. C. VERMAN, Delhi.

Importance of particle size distribution and surface area in various industries is indicated. Experimental evidence is quoted to show how both particle size distribution as well as surface area play a significant part in determining the best possible use of the materials involved in certain important applications, in which the physical properties of a product are dependant on the properties of the component parts of an aggregate mass, viz. a powder and a cementing material. Lack of theoretical background has necessitated empirical experimental procedures to be adopted in the past. For a complete understanding of the phenomena, rational interpretation of experimental data and guidance of future work with a view to improving the quality of the product and keeping costs down to a minimum, it is necessary to study the numerous mathematical problems involved. These may be divided into geometrical and physical problems, a few of which have been formulated. One illustrative problem of a highly simplified character in two dimensions has been worked out, with a view to illustrating the type of work involved and the kind of results that may be expected.

57. A simple method for determination of surface finishes

L. C. VERMAN and PREM PRAKASH, Delhi.

Extensive work has been carried out in the past few years on this subject and a number of instruments has been devised to determine the surface finish of machined parts. Almost all the instruments described in literature are of complex design and construction, sometimes costing thousands of rupees. A simple device is proposed, which involves a tilting table of old fashioned type employed for the determination of rolling and sliding friction.

In this device the surface under test is attached to the tilting table and the angle at which a spherical steel ball begins to roll is determined, just as in rolling friction determinations. The results are interpreted in terms of surface imperfections, so that the height h of the imperfection may be expressed as follows :

$$h = r(1 - \cos \theta)$$

where r is the radius of the ball and θ the angle of tilt from the horizontal.

The exact interpretation of the quantity h thus determined will have to be worked out in comparison with other more exact instruments. Judging from the constancy of h for a given surface observed by using varying sizes of balls, it does appear that the method holds promise for further development.

Raman Effect

58. Raman spectra of Ax_n type molecules

S. K. K. JATKAR, Bangalore.

The Raman spectra of AX_n type molecules have been shown to be due to vibration of A-X bond with nearly the same binding constants but with different masses such as

A-X, A-X₂, &c. The same explanation applies to the large number of Raman shifts observed by ultraviolet excitation of crystals like diamond, silica, rocksalt, etc., quantitatively.

59. Effect of temperature on the intensities of Raman lines.

K. VENKATESWARLU, Guntur.

The author has undertaken the critical and exhaustive study of the verification of the Placzek's Polarizability theory of Raman Scattering. Sharp disagreement between the theory and experiment, in respect of the absolute intensities of the Stokes and the anti-Stokes lines at different temperatures, have been noticed. The discrepancies have been explained as presumably due to the diminution in the value of $\left(\frac{\delta\alpha}{\delta q_i}\right)$ with rises of temperature. In Placzek's theory, it was customarily taken to be a constant at all temperatures.

60. Raman spectrum of naphthalene.

K. VENKATESWARLU, Guntur.

The Raman spectrum of a single crystal of naphthalene has been studied. 28 lines at $\Delta\nu$ 45, 74, 105, 126, 406, 469, 510, 731, 760, 777, 945, 1019, 1140, 1165, 1210, 1240, 1258, 1328, 1380, 1440, 1459, 1547, 1573, 1615, 3004, 3030, 3053, and 3256 cm^{-1} have been recorded. These are in fair agreement with those observed by the earlier authors. The observed external (first four) and the internal (remaining twenty four) lines are explained in relation to the structure of naphthalene.

61. The possibility of existence of the ion (HgBr_3)

P. N. SHARMA and J. R. SARAF, Lucknow.

Raman spectra of HgBr_2 (solid) and aq. solutions of $1\frac{1}{2}$ KBr. HgBr_2 and 2KBr. HgBr_2 at room temperature have been photographed. The results show the existence of the ion HgBr_3 , besides the well-known ion HgBr_2 .

62. Effect of crystal orientation on the Raman spectrum of apatite.

J. BHIMASENACHAR, Guntur.

Effect of crystal orientation on the Raman spectrum of Apatite has been studied using a single crystal. Studies have been restricted to the total symmetric line at 950 cm^{-1} . This line has been found to behave in accordance with the requirements of theory.

63. Raman spectrum of tourmaline.

B. SUNDARA RAMA RAO, Guntur.

Experimental results on the Raman Spectrum of a single crystal of Tourmaline, supplied by the Geology Dept. of the Andhra University, are reported here. With suitable filters in the path of the incident light, high-speed panchromatic plates were used to record the Raman Spectrum excited by the green line λ 5460. The following frequencies were ascertained :

$$\Delta\nu : 189, 481, 565, 623$$

$$(\frac{1}{2}s) (2b) (2b) (5v.b)$$

A very broad absorption band covering about 140 cm^{-1} has also been recorded.

Spectroscopy

64. Joshi-Effect in chlorine—emission spectrum of the excited gas.

P. G. DEO, Benares.

The emission spectrum of chlorine under the silent electric discharge which produces the new *light-effect* to a 70% of current decrease, has been investigated. An exposure of 300 hours was needed. The spectrum consists almost entirely of faint bands degraded

to the red. Two intensity maxima are observed in the regions 4900-4400Å, and 5800-5500Å. A characteristic feature of the present spectrum in contrast with that reported by Elliot and Cameron under high frequency excitation (*Proc. Roy. Soc.*, 1937, 158, 681), is the comparative absence of the atomic lines. A number of new bands, especially towards the red, have been observed. It is considered that the emission cannot be attributed to a neutral chlorine molecule, but is due to Cl_2^+ .

Rodebush and Klingelhoefer (*J. Amer. Chem. Soc.*, 1933, 55, 130) reported appreciable formation of atomic chlorine under conditions essentially similar to those reported by Elliot and Cameron. The absence, in the present spectrum, of atomic lines or an (emission) continuum characteristic of atomic recombinations, is significant. It is suggested that *under the conditions appropriate for a large light-effect* reactions involving atomic chlorine occur chiefly on the walls of the reaction vessel, viz., a Siemens' glass ozoniser. Rodebush and Klingelhoefer (*loc. cit.*) observed that solid surfaces such as e.g. glass, catalyse markedly the process of recombination. That the container walls play an important role is also suggested by the general observation that the magnitude of the *light-effect* is affected markedly by the nature of the wall material.

65. Band spectra in the flames of copper salts.

NAND LAL SINGH, Benares.

The flame spectrum of most of the copper salts shows a common continuous band in the green region. This continuum is now shown to be interspersed with line-like bands. These bands can be analysed into two systems with a common final level. The magnitude of the vibration frequency (150 cm^{-1} in the ground state) and other characteristics indicate that the emitter is very probably the diatomic copper molecule. The bands can then be ascribed to transitions between two excited 1π levels to the ground 1Σ level of Cu_2 . The continuous band also can be attributed to the Cu_2 molecule involving a transition from one or two excited 3π levels to the repulsive 3Σ state arising out of two normal copper atoms. This is probably the first evidence for the existence of diatomic copper molecules.

66. Emission bands of benzene in the quartz ultra-violet.

M. R. PADHYE, Benares.

The bands are obtained in a high frequency discharge in flowing benzene vapour. All of them are classified into a single electronic system. Though the general appearance of the bands is in some respects different from the corresponding absorption or fluorescence spectra, the analysis proves that the electronic transition involved is a common one. This transition ordinarily forbidden, occurs by virtue of a non-totally symmetric vibration being always associated with the molecule either in its normal or excited state. On the whole, the emission spectrum is much less complicated than what is expected normally for such a molecule. Probably this feature may be found common to emission spectra of many other polyatomic molecules and would no doubt prove useful if once the molecules can be excited without dissociating into their simpler constituents.

67. Structure in the continuous emission band of mercury in the neighbourhood of the resonance line 2536Å .

NAND LAL SINGH, Benares.

The band at 2536Å , has got a complicated structure. By taking a series of spectra of mercury vapour discharge excited by high frequency oscillations it is shown that there are three bands present near the resonance line of mercury, which appear at different temperatures. One band heading on 2535.9Å and shaded towards longer waves comes up at 195°C . Another band at 2540Å appears at about 210°C and is shaded towards shorter wavelengths. A third band at 2540Å appears at about 300°C which shades off towards longer wavelengths. The first two bands show asymmetrical broadening and increasing self absorption with temperature so that at 210°C the band at 2535.9Å shows a fine hair gap in the exact position of the resonance line which gap widens with temperature. This at first suggests that the band is due to the broadening resonance line.

There is, however, evidence in the present experiments which shows that the concentration of atoms decreases with temperature so much so that the spectrum at about

300°C consists mostly of bands. The fact together with the observations of Fringheim and Saltmarsh on the influence of magnetic field on the degree of polarisation of the radiation, prove that the band must be regarded as a genuine molecular band.

The three bands find a reasonable explanation in the scheme of the energy levels of diatomic mercury molecule.

68. The complex spectrum of the neutral mercury atom Hg I^b.

T. S. SUBBARAYA, Bangalore.

The spectrum designated Hg 1b is made up of lines due to transitions between terms belonging to the configurations $5d^9 6s^2 6p$, $5d^9 6s^2 6d$, $5d^9 6s^2 5f$ etc., where one inner electron is excited. Only a few such lines have been observed before and a very few terms surmised. The present author had obtained about 100 lines, most of them very diffuse, and likely to belong to Hg 1b, by employing an arc in air at atmospheric pressure, and also an electrodeless discharge, as reported at the annual session of the Indian Academy at Poona in 1944. Many of these lines have now been fitted into an array of 12 odd terms expected to belong to $5d^9 6s^2 6p$ and 16 high even terms from the configuration $5d^9 6s^2 6d$. Inner quantum numbers have been tentatively assigned to these terms. Among these terms two given by Beutler and two surmised by Murakawa have been recognised.

69. Emission spectrum of iodine between 4800 Å and 1950 Å.

P. VENKATESWARLU, Benares.

A systematic investigation of the Spectrum of Iodine vapour excited by high frequency discharge reveals many new bands and interesting details regarding these bands which have been previously studied notably among others, by Curtis and Evans. The bands distinctly belong to the so-called fluctuation type and are very complicated. A provisional analysis of the bands in the region between 4800 and 3417 Å is discussed. In this region there are four groups of bands. Each band in all the four groups has an average width of 115 cm^{-1} . This probably indicates that the four groups have a common final level. Further more, frequency differences of about 214 and 159 cm^{-1} , which occur in the first two and the last two of these groups respectively are of the order of magnitude to be expected for the excited electronic states of the diatomic molecule I_2 to which therefore, these bands may be ascribed.

Between 2880 and 2370 Å a large number of weak bands are obtained which appear to converge to a limit at 2370 Å. Between 2370 and 1950 Å occur some remarkable bands which show a very open structure. The origin of these bands is not yet very definite.

70. On the hyper-fine structure and analysis of the complex line $3842.82 \text{ sp}^3 D_3 - 5p^3 P_2$ in the first spark spectrum of arsenic in the ultraviolet region.

S. K. MUKHERJEE, Agra.

The hyper-fine structure of the complex line $\lambda 3842.82$: $\text{sp}^3 D_3 - 5p^3 P_2$, in the first spark spectrum of arsenic in the ultra-violet region has been investigated using a quartz Lummer plate and a water-cooled hollow cathode discharge tube. This line has been observed as a well resolved quartet with a coarse structure, the components degrading in intensity to the violet. These components are at intervals of 298, 278 and 162.

The predicted, graphical, resultant and observed patterns have shown fairly good agreement. The analysis has been made using the graphical method of Fisher and Goudsmit (Phys. Rev. 37, 1341 (1931)) and assuming the nuclear spin of arsenic to be $3/2$ as previously determined (*Ind. J. Phys.* 11 1937, , 123).

71. Role of line width in the measurements of the Doppler displacements in positive rays.

C. DAKSHINAMURTI, Guntur.

Doppler Effect in the mercury positive rays for the resonance radiation $\lambda 2537 \text{ Å}^\circ$ was studied with a Hilger's E₃ Quartz Spectrograph. Discharge potentials between 2000 and 24000 volts have been used. For every discharge potential used, spectra for different times of exposure, ranging between two minutes and 6 hours have been taken.

The values of the maximum Doppler displacements measured, at all the discharge potentials used, are found to be higher than the respective theoretical values, each by a constant value. The magnitude of this constant difference has been found to be equal to about half of the line width for the resonance radiation 2537\AA° . The role of the line width in the measurements is discussed. It is found to play a greater part with heavy atoms like mercury where the Doppler displacements are comparable with the line widths.

72. Absorption spectrum of lead molecule (Pb_2) in the vacuum ultraviolet region λ (600-900) \AA

B. M. ANAND, Lahore.

The absorption spectrum of diatomic lead vapour has been studied at 900, 1000, and $1,100^{\circ}\text{C}$. in the spectral region λ (600-900) \AA with a one metre normal incidence vacuum spectrograph using Hopfield Helium Continuum. An intense continuous absorption band extending between λ (671-676) \AA occurs when the lead is heated to 900°C . and broadens as the temperature is raised. This band which is being reported for the first time shows a sharp edge towards the longer wave length side.

It is postulated that the upper state involved in this absorption band is a repulsive state of $(\text{Pb}_2)^+$ dissociating into a normal neutral atom of Pb in $3p$ state and an excited atom of Pb^+ in $2p_{3/2}$ state of the electronic configuration $6s^2 7d$.

73. Traces of cobalt and nickel in certain foodstuffs.

L. SIBAIYA and (MRS) SREE, Bangalore.

Several investigations, which have been conducted to discover traces of cobalt and nickel in plants and animals, show that the occurrence of these elements is somewhat restricted. Nevertheless traces of cobalt and nickel have been definitely recorded by Berg (1926) in food-stuffs and excreta, by Newell and McCollum (1931) in marine products, by Ramage (1933), in certain tropical plants and by Mueller (1936) in human gallstones. The results of Boyd and Do (1933), who fail to discover any trace of these metals by spectrographic analysis in the whole range of food-stuffs and organs examined by them, are however irreconcilable with the findings of other investigators. Though the present chemical and spectroscopic work on certain South Indian foodstuffs has produced definite evidence of the existence of traces of cobalt and nickel, the work is necessarily incomplete as the abundance of the elements have been estimated only qualitatively on the basis of the eye-estimates of the relative intensities of their sensitive spectral lines and only a preliminary report of the findings is here given.

Difference of opinion exists with regard to the biological necessity of cobalt and nickel as well as their possible functions in nutrition. The present view seems to be that "cobalt must be considered a dietary essential" and perhaps nickel also is another. The fact that these two elements are not of universal occurrence in biological material does not preclude the possibility that they may be essential to certain forms of life. However in the hope that their specific role, if any, in metabolic processes may be revealed in due course, this investigation to detect traces of cobalt and nickel is undertaken. The result has been that in such essential foodstuffs as soyabeans (0.40 P.P.M) wheat (0.10 P.P.M.) ragi etc., traces of nickel have been established and it is surmised that nickel and also cobalt may prove to be equally essential in spite of their poor abundance. The results obtained in regard to certain vegetables, pulses and staple foods are given.

Ultrasonics

74. Supersonic velocity in gases and vapours. Part X. Relationship between the velocities in vapours and liquids.

S. K. K. JATKAR and D. LAKSHMINARAYANAN, Bangalore.

The ratio of velocities of sound in liquids at room temperature and in vapours reduced to their critical temperature, for water, alcohols, hydrocarbons, esters, halogen compounds etc. are found to be independent of temperature and the ratios are low (3-4).

for associated liquids and high (6-5) for normal liquids. The ratios which increase with molecular weight in a homologous series can be used to calculate the degree of association. This relationship is empirical.

75. Supersonic velocity in gases and vapours. Part XI. Dispersion in carbon dioxide.

S. K. K. JATKAR *and* D. LAKSHMINARAYANAN, Bangalore.

Carbon dioxide shows a dispersion even at room temperature at supersonic frequencies, as the kinetic energy $\frac{1}{2} kT$ is too small compared to the value of $\frac{1h^2}{8\pi^2 I}$ at ordinary temperatures. The values at different frequencies above 400°C. show no dispersion as kT is greater than $\frac{1h^2}{8\pi^2 I}$ above that temperature. This observed dispersion is due to the loss of rotational and not the vibrational specific heat as assumed by previous workers. The calculation of specific heats from spectroscopic data has been discussed.

76. Supersonic velocity of gases and vapours. Part XII. Specific heats of organic vapours.

S. K. K. JATKAR *and* D. LAKSHMINARAYANAN, Bangalore.

The discrepancy in the specific heats calculated from experimental data of acetaldehyde and chloroform has been quantitatively shown to be equal to the total rotational energy $3R/2$.

The supersonic velocities at 95 kc have been measured in the vapours of ethyl methyl ketone, Iso propyl acetate, secondary and iso butyl alcohols, vinyl acetate, steam, methylene chloride and Iso butyl formate, Iso and sec. butyl alcohols. Iso propyl acetate and isobutyl formate showed dispersion while the specific heats of others compare favourably with those obtained from spectroscopic data.

SECTION OF CHEMISTRY

PRESIDENT : DR. B. C. GUHA, Ph.D., D.Sc., F.N.I.

Physical Chemistry

1. Properties of synthetic mixtures of colloidal silicic acid and aluminium hydroxide*

B. CHATTERJEE, Calcutta.

Three synthetic mixtures of colloidal silicic acid and aluminium hydroxide having $\text{SiO}_2 : \text{Al}_2\text{O}_3$ ratios (molar) equal to 2 : 1, 3 : 1 and 4 : 1 which were prepared in 1944 and kept well-stoppered in Jena glass bottles have been potentiometrically titrated with bases. The titration curves show definite inflexion points between pH 7.0 and 8.5. The titration curves of the ingredients do not show inflexion points in this range of pH. The titration curves with NaOH of each of these 'aged' gels show a weak monobasic acid character, the inflexion point occurring in the range of pH 8.3 to 8.4. The $\text{Ba}(\text{OH})_2$ and $\text{Ca}(\text{OH})_2$ —curves have the appearance of those of a stronger monobasic acid and the inflexion point occurs at a lower pH (between 7.3 and 7.4). The base exchange capacities (b.e.c.) calculated at the inflexion point have almost the same value with different bases but those calculated at pH 7.0 follow the order : $\text{Ca}(\text{OH})_2 > \text{Ba}(\text{OH})_2 > \text{NaOH}$ illustrating the "irregular or specific" cation effect observed with hydrogen clays. The b.e.c. measured by titration with bases till pH 7.0 is reached increases with an increase in the $\text{SiO}_2 : \text{Al}_2\text{O}_3$ ratio. From these results and those reported previously (Chatterjee and Sen, *Indian J. Agric. Sci.*, 13, 59, 1943) it seems that "ageing" has not produced any very characteristic change in the properties of mixed gels.

The presence of the inflexion point between pH 7.0 and 8.5 in the titration curves of the synthetic mixtures of colloidal silicic acid and aluminium hydroxide with bases suggest that on mixing the sols, some sort of complex, resembling the soil absorption complex, at least in so far as their titration curves are concerned, is formed. X-ray analysis of the mixtures by Mr. S. N. Bagchi, however, failed to indicate the presence of any clay mineral in them.

2. Properties of colloidal humic acid.†

J. N. MUKHERJEE and B. CHATTERJEE, Calcutta.

In continuation of our studies on the properties of colloidal humic acid prepared from Indian soils, humic acid has been isolated from a black cotton soil from Satara District, Bombay using the method of Waksman and Stevens (*Soil Sci.*, 1930, 30, 97) and a colloidal solution of the easily peptised part having the chemical composition (C, 46.9% ; H, 3.7% ; ash 14.3%), has been prepared from it. The potentiometric titration curves show on the whole similar features as those given by the humic acid sol

*The work has been carried out under a scheme of research financed by Imperial Council of Agricultural Research, India. Prof. J. N. Mukherjee is the Director of the scheme.

†This work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

prepared from an acid soil from Jorhat, Assam (*Proc. Sci. Cong. Assam*, III, 1945). The NaOH-curve shows a weak monobasic acid character. The $\text{Ba}(\text{OH})_2$ - and $\text{Ca}(\text{OH})_2$ -curves, on the other hand, are typical of a strong monobasic acid. The inflexion points characteristic of the neutralisation of total acid occur in the range of pH 7.9 to 8.8. The base exchange capacity (b.e.c.) calculated at the inflexion points and also at pH 7.0 follows the order: $\text{Ca}(\text{OH})_2 > \text{Ba}(\text{OH})_2 > \text{NaOH}$, and illustrates the specific or irregular cation effects observed by us with hydrogen clays. Humic acid separated from the Satara soil has a b.e.c. of 490 m.e. with NaOH; 505 m.e. with $\text{Ba}(\text{OH})_2$; and 560 m.e. per 100 gms. with $\text{Ca}(\text{OH})_2$ calculated at the inflexion point in the titration curves; but that isolated from Jorhat soil has a b.e.c. of 228 m.e. with NaOH, 284 m.e. with $\text{Ba}(\text{OH})_2$, and 300 m.e. per 100 gms. with $\text{Ca}(\text{OH})_2$ also calculated at the inflexion point.

3. Apparent molal volumes of weak electrolytes.

A. S. CHACRAVARTI, Pusa.

The variation of apparent molal volume of weak electrolytes with concentration has been examined. It has been shown in several cases that the square root law: $\varphi = \varphi_0 + k\sqrt{c}$ (where φ_0 and k are constants) applicable to strong electrolytes is followed by weak electrolytes also in solutions of moderate concentration. To cover high concentrations, an equation of the type $\varphi = \varphi_0 + k\sqrt{c} + mc$ which combines the characteristics of strong electrolytes and non-electrolytes, has been successfully applied. Values of k for weak electrolytes of the uni-univalent type are small and of the same order of magnitude. For the uni-bivalent type, fairly high values of k are observed. The constant m appears to be of the same order of magnitude as k .

4. A relation between fluidity and specific volume of dilute solutions.

A. S. CHACRAVARTI, Pusa.

Batschinski's equation connecting fluidity and specific volume, $v: \phi = v \cdot w/c$ has been applied to the case of a dilute solution and pure solvent at the same temperature. Rewriting the equation in the form: $\phi = kv - m$ (for solution) and $\phi_0 = kv_0 - m$ (for pure solvent) and subtracting, we get:

$$\begin{aligned}\phi - \phi_0 &= k(v - v_0) \text{ or } (\varphi - \varphi_0)/\varphi_0 = k(v - v_0)/\varphi_0 \\ \text{or } 1 - \varphi/\varphi_0 &= A(v_0 - v), \\ \text{or } \Delta(\varphi/\varphi_0) &= A\Delta v:\end{aligned}$$

where $\Delta(\varphi/\varphi_0) = 1 - \varphi/\varphi_0$ = relative fluidity decrement of solution.

$\Delta v = v_0 - v$ = specific volume decrement of solution, and $A = k/\varphi_0$ = a constant for a particular liquid at a given temperature.

The equation $\Delta(\varphi/\varphi_0) = A\Delta v$, connotes a simple linear relation between the decrements in relative fluidity and specific volume of dilute solutions. It has been tested with a number of data and found to give very satisfactory results in dilute solutions.

5. Magneto-chemical study of the valency of nickel in arsenical nickel ores.

PRIYADARANJAN RAY and DWIJENDRA NATH SEN, Calcutta.

The valency state of nickel in arsenical nickel ores and the nature of linkage with which it binds the neighbouring arsenic atom have been determined from a measurement of the magnetic susceptibility of a sample of arsenical nickel glance and a sample of kupfer nickel. The moment values found were 1.85 and 0.74 Bohr respectively. It has been shown from a discussion of the results that in the former the metal atom occurs in the tervalent state, but the structure of the crystal is essentially homopolar with the octahedral d^2sp^3 type of bonds. This is in close agreement with the results of X-ray measurement by previous workers on arsenical nickel glance. In kupfer nickel (nickel arsenide) the moment value suggests that the Ni-As bond is neither ionic nor covalent but predominantly metallic, representing a transition between the two as a result of polarisation. The question of the valency of the nickel atom consequently does not arise here.

6. Eletro-deposition of copper from ammoniacal solution.

G. N. VASVANI, Benares.

A study has been made of the electro-depositions of copper from ammoniacal solution of copper sulphate. Results are given for the optimum conditions for the production of a smooth adherent deposit of copper in respect of the duration of electrolysis, the inter-electrode distance, the electrolyte and ammonia concentration, temperature, current density and influence of 'addition agents' such as glycerine, alcohol, hydrogen peroxide etc., and neutral salts like sodium chloride, potassium chloride, sodium nitrate etc.

The cathode efficiency attained is as much as 98% under the optimum conditions, but the metal deposition is not evenly distributed, though it is bright, smooth, and adherent. This may be attributed to the weak throwing power of the alkaline solution. With addition of the above-mentioned materials in varying amounts, the deposition was not improved. However a better and quick deposition was obtained by rotating the cathode; furthermore larger current density can be employed by increasing the velocity of rotation.

7. Influence of 'addition agents' on electromotive stability of accumulator.

S. DAMRI SINGH and SUBRAMANYA SUNDARAM, Benares.

In order to determine the influence of addition agents on the electromotive force of a lead accumulator cell, the present work was undertaken with reference to ferrous ammonium sulphate, cobalt sulphate, nickel sulphate, copper sulphate, cadmium sulphate, vanadic acid, molybdic acid, tungstic acid, oxalic acid, uranium oxide, zirconium oxide, sodium tungstate. The electromotive force was steady only in the case of zirconium oxide, tungstic acid and sodium tungstate. The rest were detrimental to the stability of the cell.

8. Influence of the acid concentration and of 'addition agents' on the plate formation in accumulator cells.

S. DAMRI SINGH and SUBRAMANYA SUNDARAM, Benares.

The present work was undertaken in order to standardise the operation of the various factors that determine the efficiency of an (lead) accumulator cell. It was found that for the formation of lead peroxide, the optimum concentration lay between 4.57N to 9.17N (Sp.Gr. 1.13 to 1.23); higher concentrations caused excessive sulphation. To study the influence of addition agents, varying amounts of Na, SO_4 , $\text{Ba}(\text{NO}_3)_2$, KNO_3 , KClO_3 , KClO_4 , were added and the resulting product was observed. KClO_3 and KClO_4 improved the quality.

9. Relative optical and heat absorption by certain inorganic salts.

P.G. DEO and P.L. SARMA, Benares.

The relative optical and heat absorptions, at different thicknesses of M/10 solutions of copper sulphate, nickel sulphate, ferrous ammonium sulphate, potassium chloride, and M/15 solution of potash alum, were investigated. Using an incandescent bulb as a light source the optical absorption was determined with an 'Osram' potassium coated photocell, and the heat absorption with a Kipps-37 thermopile.

It is observed in all cases, that the ratio of optical absorption to heat absorption varies with the thickness of the salt solution; at greater thicknesses, it tends to attain a constant value which is different in different solutions and depends on the experimental arrangement. It is found that with the copper sulphate solution the constant value is reached at a comparatively smaller thickness than in the other cases.

10. Behaviour of colloids under fields due to high frequency oscillations.

K.S. VISVANATHAN and P.L. SARMA, Benares.

The present work arose out of the results of Joshi and Purushottam (*Journ. Indian Chem. Soc.*, 1941, 18, 138) on the coagulation of a number of sols when exposed to wireless emissions from condensed sparks. Two series of observations on aluminium hydroxide and arsenious sulphide were carried out using a Parallel-Feed Hartley type oscillator so as to produce definite bands of frequencies, which were varied in the range 5 to 10 megacycles per second. In agreement with the results of Joshi and Purushottam

(*loc.cit.*) exposure to these oscillations did not produce in aluminium hydroxide over a wide range of conditions any detectable change in refractivity, which was taken as a measure of coagulation (*cf.* Joshi, *Pres. Add., Chem. Sec., Ind. Sci. Cong., 1943*). Arsenious sulphide sol, however, showed quite a marked coagulation. Under certain conditions the variations of refractivity during coagulation were found to be "zonal" or time-discontinuous as observed by Joshi and co-workers to be characteristic of coagulation in the *slow* region. This result is interesting since the coagulation is due to a non-material agency. It is considered that these changes may be attributed to the ionic and micellar oscillations in the Helmholtz double layer as induced under the applied fields.

11. Studies in the coagulation of sulphur sol.

M. N. SANKARSHANA MURTHY, Benares.

A method for preparing a sulphur sol by the combined use of electrophoresis, electrolysis and dialysis has been developed. Sulphur sol, containing electrolytes introduced on the addition of dilute hydrochloric acid to sodium thiosulphate solution during the preparation of the sol, was subjected to cataphoresis in a Hittorf transport-number apparatus for about an hour; the anolyte was then dialysed. This reduced the concentration of cations responsible for precipitating the disperse phase on the dialysing septum, which presents usual difficulty in dialysis.

Sulphur sol, thus prepared, was subjected to coagulation by the addition of electrolytes; the corresponding variation of opacity during the process was studied with the aid of a Duboscq colorimeter. The opacity increased on the whole for some time and then reached a fairly steady value. But what is more, the entire curve had marked small maxima and minima throughout its course. A theoretical explanation for this behaviour is attempted. By the combination of Smoluchowski's expression,

$$v_n = v_0 \frac{(kv_0 t)^{n-1}}{(1 + kv_0 t)^{n+1}},$$

for the number of n -fold particles at time, t , after the commencement of the quick coagulation, and Tolman's expression for the opacity of a colloidal solution, *viz.*, $I = K'/CD^2$, where I = opacity K' is a constant, C is the concentration of the disperse phase, and D is the diameter of the particles, a composite expression for the variation of opacity with time, is arrived at. By differentiating this expression with respect to time, it is found that these turning points can be theoretically predicted.

A study of the combined effect of coagulation and sedimentation on the concentration of the disperse phase, in a chosen column of the sol during coagulation, was conducted by using the turbidimeter as a nephelometer; *i.e.* the intensity of the light scattered by the particles in a particular thickness of the sol exposed to light, was used in this study. The intensity on the average increased initially, and later on diminished, but marked maxima and minima were noticed throughout the course of the curve. Theoretical treatment of this phenomenon is met with certain mathematical difficulties.

12. Magneto-chemical study of the bond type and the structure of 4-co-ordinated copper complexes.

PRIYADARANJAN RAY and DWIJENDRA NATH SEN, Calcutta.

The magnetic susceptibility of a large number (30) of complex copper compounds has been measured both at the room temperature and also, in the case of some of them, at low temperatures (-73° to -185°C) for the purpose of θ -correction. From a comparison of the moment values, particularly after θ -correction, it has been shown that the 4-co-ordinated copper complexes can be divided into two groups: one with moment values lying between 1.72 to 1.80 Bohr and the other with values between 1.90 to 2.2 Bohr. It is, therefore, suggested that in the former the bond is homopolar of the d_{sp^2} planar square type and in the latter it is either ionic or covalent of the tetrahedral sp^3 or planar sp^2d type. The lower moment value in the former results from more or less complete quenching of the orbital moment of the single unpaired electron raised to the outermost 4-p level of the atom, where it is fully exposed to the influence of the electric field of the neighbouring atoms and ions. This difference in moment value serves to distinguish between the two types of copper complexes—the penetration and associated ones, though, in both, the central copper atom contains one unpaired electron. It is also significant to note that all those complexes with lower moment values (1.72-1.80) are either black, brown, red, greenish yellow or violet blue, while others with higher moment values are green, blue or blue-violet. A relationship between the colour and the bond type or structure of the complex is thereby suggested as in the corresponding complex nickel compounds.

13. Behaviour of smokes under high frequency oscillations.

S. V. RAJ URS and M. N. S. MURTHY, Benares.

The study of the variation of electrical conductivity in smokes of tobacco, ammonium chloride, zinc oxide etc., under regimes of high frequency oscillations has yielded results of interest from the standpoint of micellar charge in aerosols. The smoke was contained in the annular space of a Siemen's type ozoniser. A simple Hartley type oscillator was employed to develop frequencies in the range of 5 to 12 mega cycles per sec. The conductivity was measured by a vacuo-junction connected to a sensitive reflection galvanometer.

The electrical conductivity of these smokes was found to increase during their life-history up to a certain maximum value and then to undergo diminution on further coagulation finally reaching a value little different from that at start. It is probable that the number of charged particles in the disperse phase increases during coagulation due to catching up of ions in the surrounding air. As ions of opposite charge coexist (Pattersons, *Phil. Mag.* 1931, 12, 1175) in aerosols when these are in sufficient number they may neutralise each other during further coalescence causing decrease of conductivity with further coagulation.

14. Study of crystals dissolved in glass.

SUBODH KUMAR MAJUMDAR, Calcutta.

The paper gives an idea of the work carried out by the author in studying the nature of crystals dissolved in a glass medium. Solid solutions of different crystals like-alkali chlorides, alkali sulphates, etc., in glasses like fused boric oxide, borax, etc., were made by fusion and the composition of the glasses was determined by the usual analytical methods. Three distinct series of measurements were made with the glasses thus obtained. First the mole-refraction was determined by measuring the refractive index in D-light and the density of the samples. The specific refraction of the glass was calculated from the Lorenz-Lorentz formula and the specific refraction of the dissolved salt was found out from the Additivity formula. The mole-refraction of the dissolved salt was found out by multiplying the value found by its molecular weight. In every case the value of R thus found is considerably less than its value in the pure crystal and in aqueous solution at infinite dilution. The inequality $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$ holds good fairly accurately in conformity with Fajans' Deformation Rule.

The spacing of NaCl dissolved in glass was next determined by the X-ray diffraction method due to Debye and Scherer. It is found that the spacing is increased to the extent of about 60% over its normal value and this enlargement of the lattice seems to be independent of salt concentration. This has been explained as due to the dielectric effect of the solvent medium.

The diamagnetic susceptibility of the glasses was then measured by a Magnetic Torsion Balance, first used by Krishnan and Banerjee. It has been found that the diamagnetic susceptibility of the dissolved salt is in every case considerably greater than its value in the pure crystalline state. This can be interpreted in the light of the Van Vleck (or the simple Langevin) theory as due to the increase of the electronic orbits which can be identified with an enlargement of the lattice. It thus appears that both the magnetic susceptibility and X-ray measurements support the idea of a widening of the lattice of a crystal when dissolved in a glass medium but the results of mole-refraction determination seem to point to a different conclusion. The matter is thus of considerable theoretical interest and requires further study.

15. Emulsion paints.

S. K. K. JATKAR and N. N. NARAYANA, Bangalore.

2.5% of magnesium oleate is a good emulsifying agent for water-in-oil emulsion. Water-in-oil emulsion is more suitable than oil-in-water. Only 20-25 parts of water can be added to get a fairly thin emulsion with dehydrated castor oil, otherwise the emulsion becomes thicker. The properties of the emulsion paint films are in no way inferior to ordinary paints.

16. Dielectric constants of polyvinyl acetate.

S. K. K. JATKAR and S. KRISHNAMURTHI, Bangalore.

The dielectric constants of vinyl acetate and its polymers have been measured in pure state and in solutions and the dipole moments calculated by using the new equation. The temperature coefficient of the dielectric constant of both vinyl acetate and polyvinyl

acetate (80,000) has been shown to follow the new equation. The moment in benzene solutions is of the same order as for pure compounds. The moment of polyvinyl acetates is proportional to the square root of the molecular weight from the monomer to 800th polymer, the increase per unit being about 1.5. The observed results have been explained on the basis of new law of dipole moments.

17. Kinetics of catalytic splitting of oils and fats.

S. K. K. JATKAR and W. S. GODBOLE, Bangalore.

Although the process of splitting of oils and fats by autoclave process using catalysts such as a mixture of lime, magnesia and zinc oxide is well known, the quantitative data on the relative activity of the various catalysts in hydrolysis of different oils and fats are not available. In the present investigation the process of splitting of coconut, groundnut, linseed, castor, tobacco seed and hydrogenated oils has been studied in presence of soaps of Mg, Ca, Na and Al, the activity being in the order given. The velocity coefficients were calculated using the uni-molecular law, the order of hydrolysis with oils being castor, coconut, linseed, hardened oil and groundnut oil. The results show that while emulsification at high temperature plays an important role the rate of hydrolysis of oil is governed by the ease of hydrolysis of the catalyst soap.

18. Alcoholysis of oils and fats.

S. K. K. JATKAR and K. R. THAKAR, Bangalore.

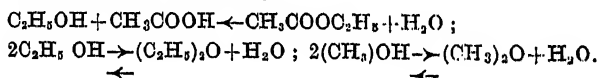
Simple methods have been developed to follow the course of alcoholysis of oils and fats. Alcoholysis of coconut, groundnut, castor, linseed and chaulmoogra oils has been studied with acid and alkali catalysts and the velocity coefficients determined. The latter has been found to be far more active than the former catalysts. With any catalyst the velocity coefficients decrease with increasing molecular weight of the oil. The alcoholysis is retarded by moisture. The temperature coefficient of velocity constants has been determined. The methanolysis goes three times faster than ethanolysis in the case of castor oil.

The superior activity of alkali catalysts has been used to carry out alcoholysis of oils on a practical basis to yield esters of fatty acids and glycerine for technical and research purposes.

19. Free energies of some organic compounds.

S. K. K. JATKAR and T. SUBRAHMANYAM, Bangalore.

The authors have calculated the free energy of organic compounds from vapour phase equilibria and thermochemical data using the specific heats calculated from spectroscopic data for the reactions:



20. Vapour-phase esterification.

S. K. K. JATKAR and T. SUBRAHMANYAM, Bangalore.

The authors have carried out experiments on the limit of esterification in vapour-phase of acetic acid with ethyl-, propyl-, and iso-amyl-alcohols using alum and active carbon as catalyst and calculated the free energy of the reaction. They have also carried out experiments on the preparation of ester from local raw materials.

21. Depolarisation of light scattered by sols.

R. S. SUBRAHMANYA, K. S. GURURAJA DOSS and B. SANJIVA RAO, Bangalore.

The effect of concentration on ρ_u , ρ_v and ρ_h has been determined by employing stearic acid sol (anisometric particles) and silver iodide sol (isometric particles) of known particle size. It has been found that ρ_u , ρ_v and ρ_h attain limiting values with the progress of dilution. These values have been found to be functions of particle size of the sols. The variation of depolarisation with concentration has been explained on the basis of multiple scattering. The temperature effect on depolarisation has also been investigated. The relationship between ρ_u , ρ_v and ρ_h and the size and anisotropy of the particles is discussed.

22. Effect of neutral salts on the determination of pH by the indicator method in the presence of wetting agents.

R. S. SUBRAHMANYA, M. R. A. RAO and B. SANJIVA RAO, Bangalore.

As reported in a previous paper there is an apparent shift in the pH of buffer solutions as measured by indicators, in presence of wetting agents. The effect of neutral salts like sodium chloride, sodium sulphate and calcium chloride on $-\Delta\text{pH}$ (the shift in pH) has been studied using thymol blue and bromophenol blue as indicators.

With thymol blue increase in the salt concentration diminishes the value of $-\Delta\text{pH}$ while with bromophenol blue the opposite effect is observed.

With calcium chloride the effect of the salt concentration on the shift of $-\Delta\text{pH}$ is far more pronounced than with the chloride and the sulphate of sodium.

These results have been explained on the basis of the formation of a complex between the indicator and the wetting agent.

23. Effect of surface active substances on the determination of pH by the indicator method.

R. S. SUBRAHMANYA, K. S. GURURAJA DOSS and B. SANJIVA RAO, Bangalore.

Effect of wetting agents on the apparent pH of acetate buffers, as shown by indicators, has been investigated. In the presence of Igepon T and Nekal Bx, bromocresol purple shows an apparent shift in pH towards the acid side. A shift towards the acid side is also observed in the tropeolin OO-Nekal Bx systems.

In the case of tropeolin OO-Igepon T systems, however, the shift in pH is towards the alkaline range. Saponin-tropeolin OO systems show a similar effect.

The observed results have been explained on the basis of complex formation between the indicator and the wetting agent. The pK values of these complexes have been calculated.

24. Effect of wetting agents on the adsorption of crystal violet on dry glass.

R. S. SUBRAHMANYA, M. R. A. RAO, and B. SANJIVA RAO, Bangalore.

The effect of pH and the effect of wetting agents on the adsorption of crystal violet on the surface of glass has been investigated. The effect of wetting agents on the adsorption of the dye has been studied at various pH values.

At low pH values, the wetting agent at first increases the adsorption of the dye. But, with an increase in concentration of the wetting agent, the adsorption falls off rapidly, and drops practically to zero. These results are explained on the assumption that the negatively charged wetting agent is preferentially adsorbed on glass and the enhanced negative charge on the surface leads to greater adsorption of the positively charged dye. With an increase in concentration of the wetting agent, however, the detergent action of the wetting agent comes into operation and causes a decrease in adsorption of the dye at the glass surface.

The results obtained, suggest a method for comparing the relative efficiencies of wetting agents as detergents.

25. A new method for the determination of the variation in boundary tension with time.

R. S. SUBRAHMANYA, M. R. A. RAO and B. SANJIVA RAO, Bangalore.

A new method for the determination of the variation in interfacial and surface tension with time is described. This method combines the advantages of the pendant drop method with those of the drop weight method, thus simplifying the apparatus considerably.

Variation with time of the boundary tension of congorubin solutions at (a) benzene and (b) air interface has been investigated. At the benzene interface, a gaseous type of film seems to be formed, while the experimental data indicate the formation of a condensed type of film at the air interface.

The variation with time of the interfacial tension with benzene has been studied, using different concentrations of the rubin solution. At higher concentrations of rubin, the fall in the interfacial tension will be large.

In the presence of electrolytes (sodium chloride, potassium iodide and acetic acid) the fall in the interfacial tension is considerably enhanced.

The slow variation in interfacial tensions has been accounted for, on the basis of changes in zeta potential.

26. Surface chemistry of congorubin solutions.

R. S. SUBRAHMANYA, M. R. A. RAO and K. S. GURURAJA DOSS,
Bangalore.

The rate of accumulation of congorubin at an air-water interface has been investigated under varying conditions of concentration and pH. The rate of accumulation increases with the increase in the concentration of the congorubin solution. The rate is also enhanced by an increase in the hydrogen-ion concentration. The results are explained on the basis of activated accumulation.

The effect of (a) acetic acid, (b) valeric acid, (c) saccharose, (d) amyl alcohol, (e) sodium stearate, and (f) Nekal Bx on the accumulation of congorubin has been investigated. With (b), (c) and (d) a fall in accumulation is noticed; while in (a) and (f) an increase is noticed. In (e), on the other hand, no change in the rate of accumulation is noticed. These results are explained on the basis of orientation of molecules.

The trough method is employed to study the variation of surface tension with time. The surface tension shows no variation during the first 15 minutes, then begins to fall and with time the fall in surface tension decreases, tending to reach the equilibrium value. The various changes observed have been explained on the basis of activated accumulation.

The surface tension measurements with congorubin in presence of stearic acid, show that the stearic acid film has the same inhibiting action on the rate of accumulation of the dye as is produced by a film of congorubin itself.

The area of cross section of the congorubin molecule has been determined by the trough method. This value supports the view that there is orientation of the congorubin molecule at the air-water interface.

27. Behaviour of alkali soaps towards some non-aqueous solvents.

MATA PRASAD, G. S. HATTIANGDI and B. K. WAGLE, Bombay.

The behaviour of sodium oleate, sodium stearate and sodium palmitate towards different organic solvents has been critically examined. It is found that these soaps do not dissolve in most of the solvents at room-temperature, but swell on heating and go into clear mobile solutions at a high temperature, near about the boiling point of the solvent; on cooling these solutions, either of the following phenomena take place, depending upon the nature of the solvent: (i) the soap remains in solution; (ii) the soap crystallises out; (iii) a gel is formed. The behaviour of the soap-solvent systems giving rise to gels has been further critically examined with special reference to the solubility of the soap and the degree of super-saturation. It is observed in all cases that if the soap content is low, crystallisation occurs when the hot soap-solvent system is cooled. With an increase in the concentration of the soap, a pseudo-gel is first formed and then a true gel when the optimum concentration of the soap is reached. It is further seen that the transition from the gelatinous flaky precipitates (crystallisation) to the weak precarious jellies (pseudo-gels) and subsequently to the typical stable gels is effected by very gentle gradations in the concentration of the soap in the system. The temperatures of crystallisation and of the formation of pseudo-gels and true gels have also been measured. In the course of measurements, some regularities have been observed in regard to the relation between the chemical character of the solvents and the phenomenon of gelation of the soap-solvent systems. In general, it is observed that in any homologous series of compounds containing an active group, the tendency to form more and more stable gels increases as the series is ascended.

28. The magnetic susceptibilities of lead salts.

MATA PRASAD, S. S. DHARMATTI and D. D. KHANOLKAR, Bombay.

A large number of organic and inorganic salts of lead have been prepared in a chemically pure state and their magnetic susceptibilities have been determined by using a modified form of Gouy balance. From the mass susceptibilities, the ionic susceptibility of Pb has been determined by taking the mean of all the values obtained by utilising various values of anions given by different authors. The theoretical susceptibility of Pb has been calculated both by Slater's and Angus's methods, and has been compared with the experimental value. The experimental value is less than the theoretical value and is nearly equal to 4/5 of it. It is also observed that the ionic susceptibility derived from the organic salts is higher than that derived from the inorganic salts by about 4 units. The ionic radius calculated from the magnetic susceptibility data is in very good agreement with the one obtained by Goldschmidt from X-ray data. A comparison made between plumbous and thallous ions, which are electronic isomers, has shown that they resemble each other in their magnetic properties.

29. The ionic susceptibility of aluminium.

MATA PRASAD, S. S. DHARMATTI and B. N. GHOSH; Bombay.

Previous workers from this laboratory have found from the magnetic study of the pure compounds of some of the elements of Group II of the Periodic Classification that there exists, in general, a difference in the ionic values obtained from inorganic and organic salts. With a view to find whether such a difference is exhibited by the elements of Group III a systematic study of the compounds of aluminium has been made.

The molecular susceptibilities of a number of aluminium salts of both organic and inorganic acids in a pure state have been measured by means of modified form of Gouy's balance. The observed experimental values have been compared with those obtained by other workers wherever available, as well as with the theoretically computed molecular susceptibility values.

The different values for the anions given by various authors have been used to calculate the ionic susceptibility of aluminium. A mean of these values has been compared with the values theoretically calculated by Slater's and Angus' methods. The mean value for aluminium ion deduced from salts of organic acid is higher than the value obtained from inorganic salts. The ionic radius of aluminium has been calculated from the corresponding ionic susceptibilities and these values are compared with the data obtained by other methods.

30. Physico-chemical investigations on the protein of silk gum. Part I. Extraction and fractionation of sericin A and sericin B from Mysore silk.

R. S. SUBRAMANYA, B. R. CHINMAYANANDAM and B. SANJIVA RAO, Bangalore.

A comparative study of the various methods for the extraction of sericin from silk has been made. The autoclave method has been found to be the best and this method has been standardised. The sericin obtained by the autoclave method has been fractionated into sericin A and sericin B. The ratio of sericin A to sericin B in Mysore silk is found to be 4 : 1. The samples of sericin A and sericin B have been analysed for carbon, hydrogen and nitrogen. It is noticed that samples of sericin A prepared by different methods have identical chemical composition.

31. Physico-chemical investigations on the protein of silk-gum. Part II. Determination of the molecular weight, viscosity, surface tension and gold number of sericin.

B. R. CHINMAYANANDAM and B. SANJIVA RAO, Bangalore.

Sericin A, purified by electrodialysis, has been employed for the determination of its molecular weight by the osmotic pressure method. The molecular weight has been found to be about 20,000. The isoelectric points of sericin A and sericin B have been determined by employing (i) viscosity measurements, (ii) surface tension measurements, and (iii) the turbidity method, using alcohol. In general, the isoelectric point of sericin A is higher than that of sericin B. The protective action of sericin has been studied by determining gold numbers and Rubin numbers. The protective action of sericin A is about ten times as great as that of sericin B.

32. Physico-chemical investigations on the protein of silk-gum. Part III. Studies on the electrophoretic mobilities of sericin A and sericin B.

B. R. CHINMAYANANDAM and B. SANJIVA RAO, Bangalore.

The electrophoretic mobilities of sericin A and sericin B have been measured with the aid of a micro-cataphoretic cell by the glass-powder method. The isoelectric points determined by a study of cataphoretic mobilities are 3.8 and 3.6 for sericin A and sericin B respectively. The effect of the salts of sodium, calcium, aluminium and thorium on the cataphoretic velocity has been studied. The first two salts do not reverse the direction but decrease the magnitude of the velocity while the last two reverse the direction.

33. Physico-chemical investigations on the protein of silk-gum. Part IV. Surface properties of sericin.

B. R. CHINMAYANANDAM, R. S. SUBRAHMANYA, and B. SANJIVA RAO, Bangalore.

The effect of pH on the limiting areas of the films of sericin A and sericin B have been studied, making use of the Langmuir-Adam surface pressure balance. It is found that

maximum spreading occurs at the isoelectric point. The influence of the chlorides of sodium, calcium and barium on the spreading of sericin has been studied. Sodium chloride gives the highest value for the area of the film. The molecular weights of sericin A and sericin B have been determined by spreading the sericin on a solution of amtrins sulphate in water. The limiting values of Force-Area happen to be the same for both the sericins. The molecular weight calculated on the basis of the Force-Area values is 16,000, for each of the sericins.

34. Autocoagulation of smokes.

M. N. SANKARSHANA MURTHY, Benares.

The autocoagulation was studied by using opacity as its measure; the system studied contained ammonium chloride as the smoke concerned. A long tube of uniform cross-section was filled with this smoke, and fixed vertically. Light of constant intensity was passed through the column of smoke, and allowed to fall on a thermopile connected to a sensitive galvanometer. The changes in the galvanometer-deflection were taken as measures of the corresponding opacity. It was found that, as in the case of sulphur sol, the opacity followed a steep rise for some time, but unlike the previous case, the opacity of the smoke attained a certain maximum and then fell more gradually than it rose previously, becoming after a certain time, practically steady, with an asymptote parallel to the time-axis. The whole course of the curve could be fully anticipated theoretically. Tolman's expression " $I = KCD$ " holds good for small particles. For large particle, the formula, also due to Tolman, is " $I = KC/D$ "; i.e., the opacity decreases with increase of particle-size when the latter exceeds a certain value. Smoke particles which are usually about ten times larger than those in hydrosols do, unlike the latter, go beyond this limit after a certain stage in their autocoagulation, and hence the observed fall in the curve in the later stages.

35. Sorption of carbon monoxide and hydrogen by ozoniser walls.

R. H. SAHASRABUDHEY and S. VEDA RAMAN, Benares.

The annular space of a Siemens glass ozoniser in which the interaction of carbon monoxide and hydrogen under silent electric discharge was produced for long periods showed very remarkable behaviour towards the components added subsequently. It was found that carbon monoxide and hydrogen admitted to the ozoniser showed a rapid pressure decrease, and this without exposure to a discharge. The rate of this pressure decrease is roughly proportional to the initial pressure. This would appear to be a case of surface adsorption either by the activated walls of the discharge vessel or some deposit from the previous carbon monoxide-hydrogen interaction. It was remarkable, however, that only a small proportion of the gas thus lost can be desorbed by even a long exposure to the discharge.

36. The variation of viscosity η_s/η_w of solutions with temperature.

A. C. CHATTERJI and RAM GOPAL, Lucknow.

In the present communication the variation of the relative viscosity η_s/η_w , where η_s denotes the viscosity of the solution and η_w that of the solvent at the same temperature, has been studied in the aqueous solutions of a large number of substances e.g., KCl, KBr, KI, KNO₃, KClO₄, Ba(NO₃)₂, BaCl₂, urea and etc., etc., at temperatures varying from 30°C to 60°C. The values of η_s/η_w have also been obtained from the data of Taimini (*J. Phys. Chem.*, 1929, i, 56) on viscosity of aqueous and non-aqueous supersaturated solutions. The results obtained appear to show that (1) in no solution where viscosity is sufficiently low the value of the temperature coefficient of relative viscosity i.e.,

$-\frac{d}{dt}(\eta_s/\eta_w)$ is negative; in other words it is always positive, (2) where the temperature coefficient of η_s/η_w is negative the solution is, in general, highly viscous except in organic solutes

The effect of concentration is to increase the factor η_s/η_w in all cases without exception. It is found that, in general, increase in the value of η_s/η_w with temperature is comparatively greater in electrolytes which show a very little attraction for water molecules e.g., KCl, KBr, KI, KNO₃ etc., as compared to those which are sufficiently solvated e.g., Ba(NO₃)₂, BaCl₂, KIO₃, K₂SO₄ etc., as well as to organic solutes. These results can be well explained on the hydration hypothesis of Rabinowisch (*J. Amer. Chem. Soc.* 1922, 44, 948) and the 'depolymerisation' concept of water molecules in presence of charged particles as advanced by Applebey (*J. Chem. Soc.*, 1910, 97, 2000) both of which have been used by Glass and Madgin (*ibid.*, 1934, ii, 1124) to explain their results on relative viscosity. It must be pointed out that range of temperatures covered here is such as

to make the solutions pass from the unsaturated into the supersaturated region in most cases. It appears, therefore, that the supersaturated solutions behave in the same way as the ordinary unsaturated solutions in this respect also.

37. The effect of heating on the limits of supersaturation.

RAM GOPAL and A. C. CHATTERJI, Lucknow.

In continuation with the previous paper (*Proc. 33rd Int. Sci. Cong. Assoc. Part III*) the effect of heating on the limits of supersaturation of aqueous solutions of various substances, both electrolytes and non-electrolytes, has been studied in greater detail with a view to find out some explanation of the anomalous behaviour of certain substances e.g., KCl, KI, KBr, KNO₃, NaNO₃, KClO₃, where heating effect is found to be almost negligible as pointed out in the previous communication. In solutions of most of the substances the effect of heating is to increase the stability of the supercooled systems towards spontaneous crystallisation i.e., to increase the value of $T_s - T$, T_s being the saturation temperature and T that of spontaneous crystallisation. An explanation based on the hypothesis of 'catalytic activity of colloidal dust particles', as advanced by Hinshelwood and Hartley (*Phil. Mag.*, 1922, 14, 78) has been advanced to explain the above anomaly taking into account the viscosity and the concentration of the medium.

38. Constitution of iodic acid, Part IV. Rheochor, parachor, and molecular refraction.

M. R. NAYAR and L. N. SRIVASTAVA, Lucknow.

The rheochor values of aqueous iodic acid have been evaluated for concentrations ranging from 0.01N to 4.0N. These results are compared with the corresponding parachor values and their proportionality established. Similar proportionality is also found in the case of rheochor and molecular refraction.

On plotting the values of rheochor of solution against concentration a curve is obtained with a break at 0.1N. When, however, solute concentration is plotted, two breaks are observed one at 0.1N as before, and another at 0.04N. These points correspond exactly with those obtained similarly with parachor and molecular refraction, as also with numerous other physical properties studied.

It is suggested that the breaks correspond to critical points in the concentration corresponding to transition from one molecular species to another brought about by polymerisation; for example, $\frac{1}{3}(\text{HIO}_3)_3 \xrightarrow{0.1\text{N}} \frac{2}{3}(\text{HIO}_3)_2 \xrightarrow{0.04\text{N}} \text{HIO}_3 \rightarrow \text{H}^+ + \text{IO}_3^-$.

The electronic constitution of the various molecular species is also discussed.

39. Constitution of iodic acid, Part V. Ionization constant.

M. R. NAYAR, Lucknow.

The ionization constant of iodic acid has been calculated employing (i) the classical or Ostwald formula, and (ii) the thermodynamic equation $K_r = \frac{\gamma^2 c}{1 - \alpha}$, where γ is

the activity coefficient and α the degree of ionization ($\alpha = \Lambda_v/\Lambda_\infty$). γ is obtained from the F.P. data of Abel, Rodlich & Rersch (1934) by graphical interpolation. On comparing the values at various concentrations it is found that K_r increases gradually up to 0.04N, remains constant between 0.04N and 0.1N and thereafter tends to decrease. These results are confirmed by a recalculation of K_r from the conductivity data of Kraus and Parker (*J.A.C.S.* 1922).

The breaks in the curve correspond exactly with the breaks in the graphs for other physico-chemical properties examined. It may be pointed out that in the case of conductivity there is no necessity to apply the mixture law equation to eliminate the effect of the solvent.

40. Kinetics of reaction of aromatic primary amines with esters of substituted benzoic acids.

N. T. VARTAK, N. L. PHALNIKAR and B. V. BHIDE, Poona.

The reaction between methyl esters of substituted benzoic acids and aniline has been studied with nitrobenzene and xylene as solvents. The reaction has been shown to be bimolecular. The activation energies have also been calculated for these reactions, and the results indicate that electronegative substituents in the *ortho*, *meta* and *para* position increase the reaction rate mainly due to the decrease in the activation energy. The effect is more marked in *para* compounds. Alkyl esters of benzoic acid react more easily as the aliphatic chain increases due to the decrease in activation energy. The

reaction is slower in aprotic solvents and does not depend on the dielectric constant of the medium.

41. Sorption of ethylene dichloride on food grains.

G. N. SUBBA RAO, K. SUBBA RAO and B. SANJIVA RAO, Bangalore.

The annual loss of food grains owing to rodent and insect damage is estimated to be about three million tons in India. The problem of preservation of food grains is becoming increasingly important. Amongst the methods of treating infested grains, fumigation is the most popular. Ethylene dichloride mixed with carbon tetrachloride is largely used as a fumigant. Vapour of ethylene dichloride was maintained at its saturation pressure and the quantity of the fumigant taken up by the grains was determined at different relative humidities, employing the quartz fibre spring technique. Jola, wheat, Bengal gram, rice (coarse variety), rice (fine variety) took 0.3 c.c., 0.4 c.c., 0.15 c.c. and 1.4 c.c. of ethylene dichloride respectively per 100 gms. of grain at 60% R.H. and 0.8 c.c., 0.9 c.c., 0.2 c.c., 1.2 c.c. and 1.5 c.c. respectively at 30% R.H. On aeration, the fumigant was completely removed from the grains. By lowering the R.H. from 60% to 30%, there was a decrease in the water content of the grains and a corresponding increase in the amount of ethylene dichloride taken. Rice, however, was an exception. The amount of ethylene dichloride taken was the same irrespective of the amount of water lost. It is of interest to note that the capillary space in rice produced by dehydration of the cereal is not available for ethylene dichloride.

42. Discontinuities and hysteresis in sorption in relation to cavity concept.

K. SUBBA RAO, Bangalore.

The success of the cavity concept as a general theory of hysteresis in sorption and other associated phenomena has been amply illustrated [Rao, K. S. J. *Phys. Chem.* 500, 45, 1941., *Current Science*, 256, 468, 546.(8). 1939., 19, 68, 70.(9) 1940]. Sorption and desorption are mainly filling and emptying of capillaries. In this paper the mechanism of filling and emptying of the cavity and open pores produced by the juxtaposition of four spheres of equiradius is considered. Expressions have been derived for the extent of filling (V) of the capillaries for different values of capillary radius. The relation between the maximum capillary radius and the relative vapour pressure (p/p_s) at which the liquid in the capillary is just in equilibrium with the vapour is given by the Kelvin equation. The graph of V against p/p_s is drawn. The mechanism reveals the following characteristics.

- (1) Existence of the hysteresis effect in the sorption and desorption processes.
- (2) Increase in the area of the hysteresis loop with increase in cavity volume.
- (3) Discontinuities in sorption and desorption. At a certain stage in the fillings of cavity there appears a bubble of the vapour which with increasing vapour pressure contracts and suddenly collapses, causing discontinuity in sorption. Similarly during emptying, the completely filled cavity is emptied suddenly instead of progressively when the neck of the cavity is just emptied. This causes a discontinuity in desorption.

According to the cavity concept discontinuities should occur only in the portions of the sorption and desorption curves forming the hysteresis loop and should be much larger in desorption than in sorption.

43. Hysteresis in the sorption of water on sericin (silk gum).

B. R. CHINMAYANANDAM, K. SUBBA RAO and B. SANJIVA RAO, Bangalore.

In the sorption of solvating liquids the behaviour of organic gels with regard to the hysteresis effect in sorption has been indicated (Rao, K. S. J. *Phys. Chem.*, 581, 46, 1941., *Current Science*, 1940, 9, 19). A study of the behaviour of sericin in the sorption of water is presented in this paper. Solid sericin isolated from raw silk was dried in vacuum and the sorption and desorption of water vapour on the sericin at 30° was studied by employing the quartz fibre spring technique. Just like rice, dhali and gum arabic, sericin exhibits the hysteresis effect in the first cycle of sorption and desorption. The hysteresis loop becomes smaller in the second cycle and completely disappears in the third. The results are explained on the basis of the disappearance of the cavities when the sericin swells on the imbibition of water.

44. Deduction of Donnan's earlier equation for membrane equilibrium.

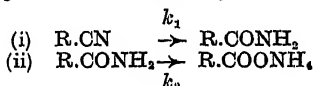
S. G. CHAUDHURY, Calcutta.

Donnan's earlier equation has been deduced from the author's theory of membrane equilibrium.

45. Kinetics of consecutive reactions : Hydrolysis of nitriles.

G. G. MUJUMDAR, K. K. DOLE and D. D. KARVE, Poona.

In continuation of the previous work on the hydrolysis of nitriles, phenyl-acetonitrile has been hydrolysed by using different concentrations of the catalysing acid and thereby changing values of the velocity coefficients, k_1 and k_2 , of the two sub-reactions.



In the case where k_1 is much greater than k_2 , the concentration of the intermediate compound increases to a maximum value and then decreases. The value of the maximum concentration depends upon the ratio k_1/k_2 , and the value increases as the value of k_1/k_2 is increased.

If k_2 is greater than k_1 , the concentration of the intermediate compound has a negligible value at any moment and the whole reaction $\text{R.CN} \rightarrow \text{R.COONH}_4$ obeys the unimolecular law fairly accurately.

It is also possible to study a case where the value of k_1 is equal to the value of k_2 ; the case is very important from the point of view of the study of consecutive reactions, since neither of the two reactions is the governing (slower) reaction. This work is at present in progress.

46. Effect of ageing and heat on the hydration of silicic acid sol.

T. BANERJEE and A. S. MD. NURUL HAQUE BHUIYAN, Dacca.

It has been confirmed by the cryoscopic and polarimetric methods that hydration of silicic acid sol increases on ageing and on heating. Our observations were extended till the bound water of the sol was about 10% when the sol set to a thick gel. The combined water of silicic acid sol was always found to be negligibly small.

47. Some new functions of viscosity similar to Irany's function of viscosity.

R. C. TRIPATHI and B. PRASAD, Cuttack.

Irany developed a function of viscosity (linear in temperature) by graphical methods. This function is linear in temperature in case of almost all the organic compounds examined. It fails in the case of some metals like gallium and tin. Irany has re-

presented the function mathematically as $\theta = \theta_1 + \frac{1.69}{1 + 1.38 \log n}$ but his function represented by

the equation, $\theta = 1.630 - \frac{2.087}{\log n + 1.282}$ has the same degree of accuracy. Moreover, it is

found that a number of functions similar to the above can be developed and all of them represent results as accurately as Irany's function does. Three of the functions

which have been examined in this paper are $f(n) = 3 - \frac{2.1}{\log n + 1.7}$

$f(n) = 5 - \frac{2.8}{\log n + 1.7}$ and $f(n) = 5 - \frac{3.5}{\log n + 1.7}$. These functions also fail in case of gallium and tin.

48. Dimorphism in sulphanilylbenzamide derivatives.

U. P. BASU and J. SIKDAR, Calcutta.

Sulphanilylbenzamide (N'-benzoyl sulphanilamide) readily dissolves in alkali, forms silver salt and the latter reacts with alkyl halide to give rise to N'-alkyl-N'-benzoyl sulphanilamide with the separation of silver iodide. The replacement of amino-hydrogen by an alkyl group under the above conditions seems to be of special interest. Conducting the reaction in presence of anhydrous boiling benzene with ethyl iodide for a period of 2 hours, benzene solution afforded a crystal melting at 183° separating in the form of elongated rectangular rods. This on hydrolysis with acid gave p-ethylaminobenzene sulphonamide, m.p. 135°, as rhombic plates. The filter from the reaction mixture con-

taining silver iodide on extracting with alcohol afforded another crop, m.p. 189°, in hexagons. This on hydrolysis also gave another *p*-ethylaminobenzene sulphonamide melting at 137° and separating in prismatic rods when crystallised from dilute alcohol. The ratio between the yield of the two varieties of *N*¹-ethyl *N*²-benzoyl sulphanilamide was almost 50 : 59.

The above derivatives gave no diazo reaction, but reacts with sodium nitrite. They readily dissolve in alkali, form silver salts but could not be further alkylated. Similarly silver salt of *N*²-benzoyl sulphanilamide on treatment with methyl iodide afforded two products; but the crop from the filter of the reaction mixture was obtained in much higher yield. Such a phenomenon of dimorphism in sulphanilamide derivatives has been noticed in sulphathiazole which also affords two methyl derivatives on methylation one being *N*²-methyl sulphathiazole and the other ring (thiazole) *N*-methyl thiazole. The question now arises whether sulphanilylbenzamide itself exists in two isomeric forms. Work is in progress.

49. Behaviour of carbon monoxide-hydrogen mixture and pure carbon monoxide under spark discharge.

R. H. SAHASRABUDHEY and S. VEDA RAMAN, Benares.

Carbon monoxide-hydrogen mixture at various pressures in the ratio 1 : 1 by volume has been subjected to spark discharge at appropriate potentials and 500 cycles frequency. The following results have been observed. (i) No perceptible time variation of pressure at 81, 95, and 108 mm. Hg; (ii) a discontinuous and apparently stepwise diminution in pressure with time at 144, 194 and 239 mm. Hg; (iii) an instantaneous explosion accompanied by blue flame at pressures near the atmospheric pressure.

Under similar conditions pure carbon monoxide did not show any time variation of pressure.

50. Interaction of carbon monoxide and hydrogen under silent electric discharge. Part I.

S. VEDA RAMAN, Benares.

Interaction of carbon monoxide and hydrogen mixture in the volume ratio 1 : 1 at pressures varied in the range 87 to 676 mm. Hg, under the silent electric discharge in a Siemens glass ozoniser at the corresponding 'threshold potentials' and 500 cycles frequency has been studied. The progress of the reaction was indicated by the time variation of the pressure and current. A marked decrease in pressure accompanied by a sensible increase in the discharge current, suggestive of a chemical reaction, is observed during the first few minutes. Subsequently, however, both the pressure and the current tend to attain a steady value. It is found that the relative decrease in pressure is greater the higher the initial pressure.

51. Interaction of carbon monoxide and hydrogen under silent electric discharge. Part II. Formation of formaldehyde.

R. H. SAHASRABUDHEY and S. VEDA RAMAN, Benares.

Formation of formaldehyde during the interaction of carbon monoxide and hydrogen subjected to a silent discharge in a Siemens type glass ozoniser at 8.1 kV and 500 cycles frequency has been observed.

The carbon monoxide-hydrogen mixture (ratio 1 : 1 by volume) at atmospheric pressure was circulated through a system of two to six ozonisers connected in parallel and subjected to discharge under the above-mentioned conditions. The gas was then washed by passing through a trap containing water to dissolve any soluble product e.g., formaldehyde. The rate of the gas-flow was measured by a flow-meter; it was varied between nine litres and five hundred forty litres per hour.

Experiments were also carried out with coatings of different substances on the ozoniser walls. With activated copper oxide, manganese dioxide, charcoal, sodium hydroxide, zinc oxide and chromium oxide, no formaldehyde was detected; mixtures of iron oxide and copper oxide, and antimony trioxide and magnesium oxide, with traces of thorium and vanadium oxides were found to catalyse the derived reaction.

52. Behaviour of carbon monoxide under silent electric discharge.

R. H. SAHASRABUDHEY and S. VEDA RAMAN, Benares.

Action of silent electric discharge on pure carbon monoxide in a Siemens glass ozoniser has been investigated over a wide range of pressures (66 mm. to 450 mm. Hg)

at the corresponding threshold potentials and 500 cycles frequency. Time variation of pressure and current have been observed. As in the case of carbon monoxide-hydrogen mixture there is an immediate though comparatively small, continuous decrease in the gas pressure concomitant with a rise in the discharge current. Both these quantities tend to approach equilibrium values with the progress of the reaction. It is remarkable that the average pressure decrease per minute should be constant in all cases.

At the end of the experiments a brown deposit was found on the ozoniser walls. It showed properties similar to those of the compound reported by Lunt (*J.C. S.*, 1925, 127, 2052).

53. Interaction of nitrous oxide and hydrogen under silent electric discharge. Part I. Production of periodic effect.

JADU NANDAN SAHAY, Benares.

The nature of the discharge reaction has been examined with particular reference to the composition of the gaseous mixture under different conditions of gas pressure, applied potential, frequency of the A. C. supply and duration of exposure, in order to determine to what extent they are responsible for the changes in pressure of the gas with respect to the duration of exposure. It has been observed that at constant applied potential higher than its threshold value and pressure of the gas above 200 mm., changes occur in the latter with the discharge reaction, when the mixture contains 31% or more of nitrous oxide. The decomposition mixture showed an initial marked rise in pressure reaching a maximum, it then fell to a minimum once again to rise and so on; through a series of recurrences whose amplitude diminished gradually, tending to become constant (cf. Joshi and Deshmukh, *Nature*, 1945, 155, 483). The outstanding features of this periodic effect now reported are that the contemporary quantities, such as the current flowing through and the energy dissipated in, the reaction space and the spectral appearance of glow due to the discharge, showed a variation which was remarkably synchronous with that of the gas pressure.

However, 29% of nitrous oxide or less produces a strikingly different result, the pressure falls, first rapidly and then sensibly slowly to a minimum constant, and remains constant under continued discharge.

54. Interaction of nitrous oxide and hydrogen under silent electric discharge. Part II. Production of zonal effect.

JADU NANDAN SAHAY, Benares.

As observed by Joshi (*Curr. Sci.*, 1939, 8, 548) the "threshold potential" required to initiate discharge at a given gas pressure, is a marked characteristic of the nature of the reaction. This has been investigated in the interaction of nitrous oxide and hydrogen under silent electric discharge. Two groups of phenomena have been observed: First is a series of time-discontinuities or "zones" as observed by Joshi and co-workers during 'slow' coagulation (Joshi, *Presi. Address., Ind. Sci. Cong., Chem. Sec.*, 1943). This zonal effect occurs when the applied potential is kept constant at V_m , during the intercourse of the change. When, however, the applied potential is raised beyond V_m , a remarkable periodicity effect is observed, similar to that reported by Joshi and Deshmukh (*Nature*, 1945, 155, 483) consisting of a series of recurrences in which the pressure and the discharge current vary through maximum and minimum.

55. Interaction of nitrous oxide and hydrogen under silent electric discharge. Part III. Effect of moisture.

JADU NANDAN SAHAY, Benares.

The present investigation was undertaken in order to find out if the presence of moisture was responsible for the occurrence of the 'periodicity effect' which is found to be a peculiarity of this reaction under certain conditions. The experimental procedure consisted mainly in following the time variations in the pressure of the reaction mixture and the corresponding current in the presence of varying amounts of moisture introduced before the application of the discharge. The results show that the occurrence of this periodicity effect is independent of the presence of moisture. It may be recalled that no periodicity effect was observed when moisture alone was subjected to the silent electric discharge under a wide variety of conditions (Joshi *Presi. Address., Chem. Sec., Ind. Sci. Cong.*, 1943).

56. Interaction of nitrous oxide and hydrogen under silent electric discharge. Part IV. Effect of high and low frequency current.

JADU NANDAN SAHAY, Benares.

That the frequency of the discharge current plays an important part in the velocity of the reaction is another point of interest to be noted in this connection. The periodic effect which is produced at a certain applied potential and 50 cycles per seconds frequency, is not observed at the corresponding potential and 500 cycles frequency and also under a spark discharge. In the latter case the course and the velocity of the discharge reaction are greatly changed. The periodicity effect can be restored by reverting to exposure at the lower frequency, even after the occurrence of a part of the reaction, at the higher frequency, when there is no periodic effect.

As observed by Joshi and Deshmukh, the glow of the discharge also varies periodically from intense pink violet to light pink violet with the diminution of the pressure and *vice versa*. At 500 cycles frequency the pink violet glow from the reaction mixture remains practically unaltered during the entire course of the reaction.

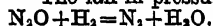
57. Interaction of nitrous oxide and hydrogen under silent electric discharge. Part V. Mechanism of the reaction.

JADU NANDAN SAHAY, Benares.

The suggested mechanism of the reaction is as follows: the reaction is of the chain type, initiated by the O atoms derived from the dissociation of N_2O molecules and propagated by H atoms and OH^\cdot radicals. Termination of the reaction occurs mainly in the gas by the combination of H atoms, but some may take place on the walls.

As suggested by Joshi and Deshmukh this first initial sharp rise in the pressure consists chiefly of the conversion of N_2O into NO and atomic N, with the subsequent formation of N_2 and atomic O. The slower rise in pressure at the later stage can be accounted for by the formation of nitrogen-trioxide and nitrogen dioxide as an intermediate stage. Hydrogen apparently remains unacted during the stage when the pressure rises.

The fall in pressure follows the equation, suggested by Joshi and Deshmukh:



58. Effect of the electric field on the degree of depolarisation of colloidal solutions.

M. R. ASWATHANARAYANA RAO, J. C. GHOSH and R. SUBRAMANYAM, Bangalore.

The variation of the degree of depolarisation with the electric field has been investigated using the following colloidal solutions:—(1) Stearic acid, (2) Vanadium pentoxide and (3) Benzopurpurin. The depolarisation factors, ρ_v , ρ_v , ρ_h for unpolarised, vertically polarised and horizontally polarised light respectively have been measured using the electric field (1) perpendicular to the incident beam and the direction of observation (2) perpendicular to the incident beam but parallel to the direction of observation and (3) parallel to the incident beam but perpendicular to the direction of observation. With increase in voltage it was found that with stearic acid ρ_v , ρ_v and ρ_h decreased in the vertical field and increased in the two horizontal fields, with vanadium pentoxide ρ_v and ρ_h decreased and ρ_h increased in the vertical field and ρ_v and ρ_h increased and ρ_h decreased in the horizontal fields, and with Benzopurpurin, ρ_v and ρ_h decreased and ρ_h increased in the vertical field and ρ_v and ρ_h increased and ρ_h decreased in the horizontal fields. The relationship between the anisotropy of the particle and the variation of the depolarisation factor has been discussed.

59. Effect of wetting agents on the electrophoretic velocity of the latex particles.

R. SUBRAMANYAM, J. C. GHOSH and M. R. ASWATHANARAYANA RAO, Bangalore.

The effect of wetting agents on the electrophoretic mobility of the latex particles has been studied using the following wetting agents:—(1) sodium oleate, (2) Nekal bx, (3) surfax and (4) Igepon T. When the pH of the latex solutions is on the alkaline side of the isoelectric point, the addition of wetting agent diminishes the mobility of the latex particles. But on the acid side of the isoelectric point, the addition of the wetting agents reverses the charge on the latex particles. The effect of concentration of the detergent on the latex particles has also been investigated. With Nekal bx, however,

charge reversal takes place when the pH of the solution is brought to about 0.7 and below this value the reversal of the charge does not occur. These results have been explained on the basis of adsorption of the wetting agent by the latex particles.

60. Surface chemistry of rubber latex.

R. SUBRAMANYAM, J. C. GHOSH and M. R. ASWATHANARAYANA RAO,
Bangalore.

The surface chemistry of dialysed latex solutions has been investigated using the trough method of Adam and Langmuir. The results indicate that latex solutions give a condensed type of surface film. With increase in time the area of the film also increases till practically the whole surface is covered within about 40 minutes. The increase in the concentration of the latex accelerates the rate of formation of the film. Salts at very low concentrations do not appreciably alter the rate of formation of the film. The maximum value for the rate of formation is obtained at the isoelectric point of the latex. The significance of the results obtained is discussed.

61. Variation of surface tension with time of latex solutions.

R. SUBRAMANYAM, J. C. GHOSH and M. R. ASWATHANARAYANA RAO,
Bangalore.

The surface tension of dilute latex solutions has been investigated employing dialysed latex. It is noticed that the surface tension diminishes with time. The rate of fall of surface tension with time has been shown to depend on (1) the concentration and (2) the salt content of the latex solutions employed. The effect of pH shows that the fall in surface tension is maximum for high values of the pH.

62. Effect of ageing on the conductivity of sols.

S. D. JHA, Delhi and S. GHOSH, Allahabad.

In this paper we have investigated the changes in electrical conductivity of the sols of stannic hydroxide, ferric phosphate and vanadium pentoxide on ageing. The nature of the changes taking place in this property, depends upon the behaviour of colloidal particles and concentration of the sol. The changes have been more prominent in the case of most dilute sols. In general, the adsorption capacity of the particles decreases on ageing, resulting in an increase in electrical conductivity, except in some cases where some of the substance, present in solution, polymerizes to give some complex aggregates, causing a decrease in conductivity.

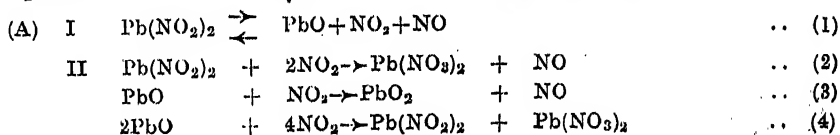
63. Thermal decomposition of lead nitrite and lead nitrate.

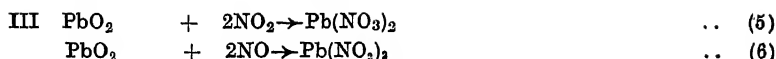
M. S. SHAH and P. G. SHETH, Ahmedabad.

In continuation of the work on the thermal decomposition of lead nitrite, attempts have been made to study the thermal decomposition of lead nitrate by heating a known quantity of the substance in vacuo at various temperatures and analysing quantitatively the solid and gaseous products of the decomposition. The decomposition which is slow at 360°, gains speed at 400° and is fairly rapid at 440°.

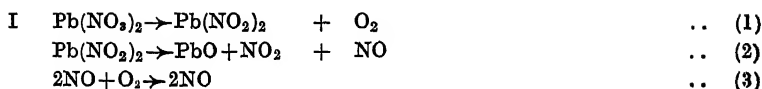
In order to get further insight into the mechanism of the decomposition of (A) lead nitrite and (B) lead nitrate, series of experiments were next undertaken to study (a) the decomposition of lead peroxide, (b) the influence of nitrogen peroxide on (i) lead nitrite, (ii) litharge and (iii) Lead peroxide (c) the influence of nitric oxide on (i) lead nitrite, (ii) lead nitrate, (iii) litharge and (iv) lead peroxide at various temperatures. Experiments were also conducted to elucidate the effect of litharge and lead nitrite on the decomposition of lead nitrate.

The results of all the above experiments show that the reactions involved in the decomposition of (A) Lead nitrite and (B) Lead nitrate are as given below :—





(B)



64. Studies on the reaction between sodium citrate and iodine Part I. Reaction in the dark

K. VEERIAH, Hyderabad-Dn.

The reaction between sodium citrate and iodine does not take place with any appreciable speed at room temperature in the dark. However, at higher temperatures it is found that the reaction gathers speed and takes place with a measurable velocity. The reaction does not seem to obey any order and the velocity coefficients calculated according to zero, semi-or unimolecular formula show a rapid fall in their values with time. The falling off of the velocity coefficients is due to the existence of another reaction between sodium citrate and iodine which takes place very rapidly on mixing the two solutions. The effect of temperature, concentration of citrate and iodine and the effect of Cr^{+++} , Mn^{++} , Fe^{++} and Fe^{+} ions on this initial reaction have been studied. It has been noticed that Fe^{+} and Fe^{++} ions form complexes with sodium citrate in which they are present in the electronegative part of the molecule.

65. Studies on the reaction between sodium citrate and iodine Part II. Reaction in the dark in presence of Cr^{+++} , Mn^{++} , and Fe^{+++} ions.

K. VEERIAH, Hyderabad-Dn.

The reaction between sodium citrate and iodine has been studied in the dark in the presence of Cr , Mn , and Fe ions. The reaction is accelerated by Cr , and Mn ions, while Fe ions seem to exert a slight retarding influence. The reactions in the presence of Cr^{+++} , Mn^{++} , and Fe^{+++} ions are of the zero order. The temperature coefficients in the presence of Cr^{+++} , and Mn^{++} ions have been determined between 30° and 60° C. They are nearly as high as those found for similar but uncatalysed reactions between iodine and other organic salts such as potassium oxalate and sodium formate. The reaction catalysed by Mn^{++} ions exhibits a long induction period which diminishes with a rise in temperature. At room temperature induction period extends to several hours. The effect of the concentration of Mn ions, iodine, sodium citrate and potassium iodide on induction period as also the effect of the concentration of the metallic ions over the rate of the reaction have been studied. In the presence of Cr^{+++} and Mn^{++} ions the reaction is accompanied by the formation in small amounts of a yellow solid compound which has been identified as iodoform.

66. Studies on the reaction between sodium citrate and iodine Part III. Reaction in light in the absence and presence of Cr , Mn and Fe ions.

K. VEERIAH, Hyderabad-Dn.

The reaction between sodium citrate and iodine has been further investigated in the light of 1000 watt tungsten filament lamp. As shown in the paper communicated last year, (*Proc. 32nd Ind. Sc. Cong. 1944. Part III. p. 123*) the reaction is negligible at room temperature both in the light of the lamp as well as in sunlight, being considerably accelerated by light in the presence of Cr^{+++} and Mn^{++} ions, ferric ions, however, having very little effect on the reaction. The reaction in light in the presence of metallic ions is found to follow the zero-molecular law like the dark catalysed reactions. In the presence of Mn^{+++} ions, the reaction exhibits an induction period, which is not usually shown by the reaction in the presence of Cr^{+++} ions. The temperature coefficients have been determined between 30° and 60° C. Both temperature co-efficients and induction period are lower in the case of the light reaction as compared to the dark reaction under similar conditions. In the presence of Mn^{++} ions a pale yellow solid compound is obtained which has been identified as tetra-iodoacetone.

Inorganic Chemistry

67. Adaptation of thermometric titration of Dutoit in a new rapid estimation of magnesium and calcium in dolomites, magnesites etc.

P. B. SARKAR, Calcutta.

The method of thermometric titration was first employed by Dutoit and Grobel in the investigation of different types of reactions as early as 1922. Later in 1928 Mayr and Fisch extended the method to the study of a number of oxidation-reduction and precipitation reactions. The present author has estimated Mg and Ca both separately and when they are present together by the thermometric method and also studied the range of applicability of the method in both cases. Magnesium solution is titrated with a standard microcosmic salt solution in presence of ammonium chloride and ammonia. Best results are obtained when the concentration of ammonium chloride and ammonia are 2.5 grams and 5 c.c. (conc. NH_4OH) respectively per 0.1 gm. of Mg present in the

solution up to a concentration of $\frac{M}{50}$ Mg. The results are very good and agree within

0.0-3% with that obtained by gravimetric estimations either as magnesium pyrophosphate or 8-oxyquinolate. The characteristics of the curve are explained. In concentrated solutions both in the cases of Ca and Mg, indications of the formation of intermediate products such as CaCl_2 , CaC_2O_4 , and chlorowagnerite are obtained. In the

case of calcium the method is applicable down to a concentration of $\frac{M}{30}$ Ca.

Five different samples of dolomite were examined. The best experimental condition is as follows:—2.5 grams of the ore are dissolved in HCl, the required quantity of NH_4Cl is added and the solution precipitated with ammonia, bromothymol blue being used as indicator. Iron, aluminium and silicon are precipitated. After filtration, the solution is brought to $\text{pH} 4.2$ by adding a few drops of glacial acetic acid (with Wesselow's indicator) and made up to a volume of 250 c.c. 50 c.c. of this solution are used for each titration. The results are as good as any gravimetric method, whereas the time taken for one complete analysis by the present method is barely 1-1½ hours. (In case of magnesium a computation factor of 1.01 was found necessary).

68. Mechanism of the reaction between yellow phosphorus and a solution of caustic soda when kept together on a boiling water-bath.

G. B. KOLHATKAR, Poona.

Caustic soda and water act simultaneously on yellow phosphorus and form sodium dihydrogen hypophosphite and hydrides of phosphorus. The action of water at 100° on yellow phosphorus is found to be very feeble. It is, therefore, caustic soda in the solution which first acts on phosphorus, liberates nascent hydrogen and forms the sodium salt of the hypothetical meta hypophosphorous acid, which then immediately combines with water to form sodium dihydrogen hypophosphite. The acceleration of the reaction with increase in the concentration of caustic soda in the solution supports this conclusion. The nascent hydrogen liberated mainly forms molecular hydrogen when a dilute solution of the alkali is used but in a concentrated solution a considerable amount of the hydrogen combines with phosphorus to form hydrides of phosphorus.

69. Studies on the formation of the complex compounds of potassium chloride and mercuric chloride. Part III.

L. N. SRIVASTAVA, Lucknow.

Experiments on conductivity and viscosity of mixtures of potassium chloride and mercuric chloride in aqueous solution indicate the formation of complex compounds of the molecular formulae $2\text{KCl} \cdot \text{HgCl}_2$, $\text{KCl} \cdot \text{HgCl}_2$, and $\text{KCl} \cdot 2\text{HgCl}_2$. The formation of these compounds has been established, and a fourth one of the formula $2\text{KCl} \cdot 3\text{HgCl}_2$ also appears to exist in solution.

Rheochor of the solution and solute was calculated and the results confirm the formation of the above-mentioned compounds.

70. Complex compounds of cobalt with propylene diamine bis acetyl acetone : Resolution of diaminopropylene diamine bis acetyl acetone cobaltic bromide.

KANAI LAL MANDAL, Calcutta.

Cobaltic chloride hexahydrate in presence of sodium hydroxide gave orange-red prisms of diaquo cobaltous propylene diamine bis acetyl acetone, $(\text{H}_2\text{O})_2 \text{Co C}_3\text{H}_7\text{O}_2 \text{N}_2$. In its tricyclic system of the three chelate components, all the rings are six-membered. It was readily decomposed by mineral acids into acetyl acetone and cobaltous and propylene diamine salts.

The compound was oxidised by hydrogen peroxide in presence of ammonia and ammonium chloride giving diaminopropylene diamine bis acetyl acetone cobaltic chloride dihydrate $(\text{NH}_4)_2\text{CoC}_3\text{H}_7\text{O}_2\text{N}_2\text{O}_2 \cdot 2\text{H}_2\text{O}$ which yielded the other less soluble salts by double decomposition with sodium and potassium salts of the corresponding acids. When the *d*-camphor sulphonate was fractionally crystallised and the second fraction was treated with potassium bromide, a dextro-rotatory bromide was obtained.

71. On the characteristics of magnesium trisilicate.

S. MUKHERJEE, K. K. DAS-GUPTA and R. P. BANERJEE.
Baranagar (Calcutta.)

'Synthetic' magnesium trisilicate, $\text{Mg}_2\text{Si}_3\text{O}_8 \cdot n\text{H}_2\text{O}$, prepared from sodium silicate and magnesium sulphate and artificial mixtures containing hydrated MgO and SiO_2 in the same proportions as in the synthetic compound have been compared by potentiometric titrations with HCl and determinations of total antacid power (B.P., 1932, 4th Addendum), "lag value" (Surfleet and Porter, *Q.J.Ph. Pharmacol.*, 1940, 13, 109) and adsorption of methylene blue. Mixtures prepared under different conditions show differences in "lag value". The synthetic silicate has a higher adsorbing power for methylene blue than the mixtures. In the potentiometric titrations the maximum buffer action takes place between pH 6 and 7 for the synthetic compound and between pH 7 and 8 for the mixtures. This indicates the possibility of using potentiometric titration as a means of distinguishing true magnesium trisilicate from artificial mixtures.

72. The effect of ferric oxide on the thermal decomposition of calcium sulphate-boric oxide mixtures.

S. M. MEHTA and T. R. RAO, Bombay.

In continuation of the work described previously by Mehta & Cooper (*Proc. Ind. Sc. Congress*, 1937, 124) the effect of the addition of ferric oxide prepared by different methods on the decomposition of the calcium sulphate-boric oxide mixtures was investigated. It was found that the sample prepared in the laboratory by a dry method gave better results than the one prepared by other methods. It is found that addition of a small amount of ferric oxide has a catalytic effect on the decomposition of calcium sulphate in the presence of boric oxide. It also increases the yield of sulphur trioxide in the products of decomposition and brings about a higher decomposition of calcium sulphate than in its absence.

73. Solubility of the red, yellow and green samples of lead monoxide in solutions of sodium hydroxide.

S. M. MEHTA and D. L. DESAI, Bombay.

The solubilities in solutions of sodium hydroxide of pure samples of red, yellow and green forms of lead monoxide were measured for concentrations between 4N and 14N and at temperatures between 30° and 45°. For this purpose the samples used were those which showed the maximum density. It was found that the solubilities of the different samples are in order green > yellow > red which is the reverse of the order of the densities of these samples.

74. Preparation of differently coloured samples of lead monoxide.

S. M. MEHTA and D. L. DESAI, Bombay.

Conditions have been standardised for the preparation of the red, yellow and green samples of lead monoxide in a state of purity. The red and the green samples were ob-

tained by the interaction of lead acetate and sodium hydroxide of definite concentrations. The yellow sample is obtained by treating the orange-coloured commercial sample with 10N NaOH. During an examination of the conditions under which the green crystals were obtained, it was noticed that the change in the concentration of alkali gave crystals with varying shades of green. A concentration of alkali above 6N tended to give samples which increased in yellowness in tint until with 10N alkali a pure yellow sample was obtained. The observation of this phenomenon led to a study of the nature of the substances obtained when the alkali concentrations were changed from 10N to 18N. From the results on the density measurements of these samples, it is shown that the samples used by different investigators were not single substances but were probably mixtures of different modifications. The widely different results obtained by different workers as given in the literature are explained on this hypothesis.

75. Reaction between disodium hydrogen phosphate and mercuric chloride.

S. M. MEHTA and N. B. PATEL, Bombay.

In the reaction between aqueous solutions of disodium hydrogen phosphate and mercuric chloride a yellow intermediate substance is first produced which gets transformed with further interaction with the mother liquor into a reddish-brown or black precipitate. This yellow intermediate substance was first isolated by Mehta and Sheth (*Journ. Uni. Bombay*, 1937, 6, 75). They found as a result of the analysis of this substance that it is neither pure mercuric oxide nor mercuric phosphate but probably a mixture of the latter with an oxychloride of mercury. This substance has now been isolated in quantity and it is shown that it is a mixture consisting of basic phosphate $2\text{HgO} \cdot \text{Hg}_3(\text{PO}_4)_2$ and the oxychloride $\text{HgO} \cdot \text{HgCl}_2$. It is also shown that this yellow intermediate substance reacts with the sodium chloride formed in the reaction and is thereby converted into the reddish-brown or black oxychloride of mercury.

76. Studies in mercuric phosphates.

S. M. MEHTA and N. B. PATEL, Bombay.

Conditions have been standardised whereby tertiary mercuric phosphate has been obtained by the reaction between aqueous solutions of disodium hydrogen phosphate and mercuric nitrate. By adjusting concentrations of mercuric nitrate and temperature it has been possible to isolate basic mercuric phosphate of definite composition and also the double salt of sodium phosphate with tertiary mercuric phosphate. The effect of heat on the different mercuric phosphates was also examined and it is found that tertiary mercuric phosphate apparently melts at 680° but that this in reality is the melting point of mercuric pyrophosphate formed as a residue after the decomposition of mercuric phosphate. Mercuric pyrophosphate was prepared according to the method of Schwartzzenberg and it was found to melt at the same temperature *viz.* 680° .

Organic Chemistry

77. Chemical study of the seeds of Sarda (*Cucumis Melo*) Linn.

D. R. DHINGRA and SHAMSUDDIN ALI AHMED, Delhi.

Component fatty acids of Sarda (melon) seed fat from Baluchistan are: Myristic 2.0%, palmitic 3.2%, stearic 5.5%, arachidic 0.9%, oleic 32.9%, linoleic 55.5%. There is a broad similarity of their component fatty acids with those of the Punjab melon (Kharbuza) seed oil (Dhingra & Prem Narain, Forthcoming publication in *J. Ind. Chem. Soc.* 1945).

The kernels contain 44.6% oil, 35.8% proteinous substances, 3.0% phosphates (as P_2O_5) and 5.6% ash. Ash contains iron, potassium phosphate, silica and traces of calcium.

The seed kernels form a very good substitute as an article of nourishing food, for the more expensive almond kernels. Oil also is of a pleasant odour and taste and can very well substitute almond oil for medicinal and edible purposes.

The acids are evenly distributed in the glycerides.

78. Preparation of ethyl chloride and ethyl nitrite.

S. K. K. JATKAR and T. SUBRAHMANYAN, Bangalore.

The authors have described in detail preparation of ethyl chloride, ethyl nitrite for pharmaceutical and industrial purposes.

79. Chemical examination of the fatty oil from Mysore race *Chrysalis* (silk pupa).

H. SUBBA JOIS and J. R. LAKSHMANA RAO, Bangalore.

The dried sample of Mysore race *chrysalis* (silk pupa), a bye-product of silk industry, was extracted with petroleum ether in a Soxhlet and found to contain 24.8% of a fatty oil, brown in colour. Various constants of the fatty oil have been determined.

80. New mercury derivatives of phenols.

KHALILUR RAHAMAN and S. S. GUHA-SIRCAR, Dacca.

Corresponding to acetoxy mercuri-derivatives of phenols, benzoyloxy, salicyloxy and lactoxy-mercuri-derivatives of *o-m*, and *p*-nitrophenols, of *o*- and *p*-chlorophenol and of thymol have been prepared. The comparative bactericidal actions of their sodium compounds on *B. Coli* have been determined at different dilutions.

81. Some new sulphanilamide derivatives.

ISMAT ALI and S. S. GUHA-SIRCAR, Dacca.

Two iodo-derivatives, eight azo-derivatives, *N*-acetic and propionic acids, and a number of mercuri-derivatives corresponding to acetoxy mercuri-compounds of aromatic amines have been prepared from sulphanilamide. The bactericidal actions of their sodium compounds on *B. Coli* have been determined. The activities are low, but are higher than that of the unsubstituted drug.

82. Complex nickel salts with propylene diamine bisacetyl acetone.

KANAI LAL MANDAL, Calcutta.

Nickel salts have been found to give with propylene diamine bis acetyl acetone, a nickel compound $C_{12}H_{20}N_4O_4Ni$. All the rings in the compound are six-membered. This compound which is co-ordinatively unsaturated has yielded addition compounds with a molecule of propylene diamine, two molecules of pyridine and two molecules of ammonia thus differing from cupric propylene diamine-bisacetyl acetone, two molecules of which combine with a molecule of propylene diamine. The addition compound of nickel propylene diamine bis acetyl acetone with ammonia is very unstable. The co-ordination valency of nickel in the additive nickel salts is evidently six.

83. Studies in Friedel and Craft's reaction. Part I : Condensation of succinic and phthalic anhydrides with iodo-toluenes.

K. R. IRANI, N. L. PHALNIKAR, B. V. BHIDE and K. S. NARGUND, Poona.

o-, *m*-, and *p*-Iodo-toluenes when condensed with succinic and phthalic anhydrides, in the presence of anhydrous aluminum chloride using nitrobenzene as solvent, give β -*p*-toluoyl-propionic acid (m.p. 127°) and *o*-(*p*-toluoyl)-benzoic acid (m.p. 140°) respectively. In all cases iodine is completely removed. The corresponding chloro-, and bromo-toluenes have been condensed with phthalic anhydride but dehalogenation has not been observed (Heller and Schulke, *Ber.* 41, 3627; *Ber.* 45, 792, 1912). Iodo-toluenes on heating with aluminum chloride alone liberate iodine. On these observations a mechanism of the process has been proposed.

84. Studies in Friedel and Craft's Reaction. Part II : Condensation of halogenated anisoles with phthalic and succinic anhydride.

K. R. IRANI, N. L. PHALNIKAR, B. V. BHIDE and K. S. NARGUND, Poona.

o-, *m*-, and *p*-iodo-anisoles were condensed with phthalic and succinic anhydrides in the presence of anhydrous aluminum chloride using nitrobenzene as solvent.

o- and *p*-iodo-anisoles with phthalic anhydride gave the same *o*-(*p*-methoxybenzoyl) benzoic acid (m.p. 148°) while *m*-iodo-anisoles gave an acid (m.p. 130°) which has been shown to be *o*-(2-iodo-4-methoxybenzoyl)-benzoic acid.

With succinic anhydride and *p*-iodo anisole β -(*p*-methoxybenzoyl)-propionic acid (m.p. 146°) was obtained. *o*-Iodo-anisole under similar conditions gave β -(3-iodo-4-

methoxy-benzoyl)-propionic acid (m.p. 180°) while *m*-iodoanisole gave β -(2-iodo-4-methoxy-benzoyl)-propionic acid (m.p. 134°).

o- and *p*-bromoanisoles have also been similarly condensed with succinic anhydride and β -(3-bromo-4-methoxybenzoyl)-propionic acid (m.p. 188°) and β -(5-bromo-2-methoxy benzoyl)-propionic acid (m.p. 122°) respectively have been obtained.

Chloro-anisoles have also been condensed with succinic anhydrides but no dehalogenation has been observed.

85. Condensation of mono-alkyl ethers of resorcinol with succinic anhydride.

K. R. IRANI, N. L. PHALNIKAR, B. V. BHIDE and K. S. NARGUND,
Poona.

Nargund and Dalal (*J. I. C. S.*, 1937, 14, 406), have condensed resorcinol monomethyl ether with succinic anhydride and have obtained β -(4-methoxy-2-hydroxy-benzoyl) propionic acid. Similarly in the present work mono-alkyl ethers of resorcinol (alkyl groups: ethyl, propyl, *n*- and *iso*-butyl and *iso*-amyl) have been condensed with succinic anhydride and the corresponding β -4-alkoxy-2-hydroxy-benzoyl-propionic acids have been obtained. These acids are being converted into the γ -(4-alkoxy-2-hydroxy-phenyl) γ -butyrolactones with a view to testing their anthelmintic properties.

86. Chemical investigation of the seeds of *Argyria speciosa*. (N. O. Convolvulaceae).

G. M. KELKAR, N. L. PHALNIKAR, and B. V. BHIDE, Poona.

Argyria speciosa (elephant creeper) grows abundantly in India and its seeds are used considerably in Ayurvedic medicine. The seeds yield a semi-drying oil which has been found to contain glycerides of oleic (33.23%), linolic (18.17%), linolenic (6.09%) acids and palmitic (6.73%), stearic (10.12%) and behenic (6.63%) acids. The presence of behenic acid is significant.

The seeds also contain an alkaloid which is easily decomposed on exposure to air. The ash of the seeds contains a large amount of phosphates.

87. Preparation of albucid. (Acetyl sulphonamide).

S. C. NIYOGY, Calcutta.

The present work deals with a new and improved method of preparing N_1 -acetyl sulphonamide which is extremely used for the treatment of urinary infections. On account of the difficulty in obtaining raw materials, the present method which deals with the preparation of N_1N_1 -diacetyl sulphonamide and regulated hydrolysis of the same to N_1 -acetyl derivative with the use of the smallest quantity of acetic anhydride will prove to be of great value.

88. Total synthesis of thujone.

M. S. MUTHANNA and P. C. GUHA, Bangalore.

Ruzicka and Koolhass effected a partial synthesis of thujone from thujaketonic acid, the immediate degradation product of thujone. Thujaketonic acid having already been synthesised by us from thujadicarboxylic acid and the synthesis of umbellularic acid also having already been achieved, for the total synthesis of thujone, it only remained to synthesise thujadicarboxylic acid from umbellularic acid. This has now been accomplished.

89. Fixed oil from the seeds of *Swietenia Macrophylla*.

A.N. POTI and K. RAMACHANDRAN NAIR, Trivandrum.

The seeds of *Swietenia Macrophylla* on extraction with light petroleum (50-60°) gave 58% of a pale yellow coloured oil possessing a bitter taste. The oil had the following physical and chemical constants:

Specific gravity (31°)	= 0.9240
Refractive index (31°)	= 1.4782
Acid value	= 1.01

Polenske value	= 0.32
Reichert-Meissel value	= 3.4
Saponification value	= 190.4
Acetyl value	= 9.63
Iodine value (Winkler)	= 93.3
Unsaponifiable matter	= 1.5%

The oil was found to contain 82.2% of total fatty acids which on resolution were found to contain 31.5% of solid acids and 68.2% of liquid acids. The solid acids consist of stearic and palmitic acids while the liquid acids consist of linolenic (4%), linolic (12.4%) and oleic acids (83.6%).

The seeds after extraction of the oil by light petrol when again extracted with alcohol furnished an intensely bitter substance. The investigation of this bitter product is in progress.

90. Some substituted amides of diphenylamin-4 : 4'-disulphonic acid.

R. T. THAMPY, B. H. IYER and P. C. GUHA, Bangalore.

Although diphenylamin-4 : 4'-disulphonic acid and a few of its salts have been known its disulphochloride and the diamide have not been prepared before. By the action of PCl_5 on diphenylamin-4 : 4'-disulphonic acid, its dichloride was prepared. But it could not be isolated in a sufficiently pure form for analysis. It was always obtained as a dark pasty mass and attempts to purify it led to its decomposition. Therefore, the non-purified product, after freeing it from phosphorous oxychloride was used as such in its condensations with ammonia, aniline, *o*-, *m*-, and *p*-toluidines, *o*-, *m*-, and *p*-xylydines, and *o*-anisidine when the following compounds were obtained :

1. Diphenylamin-4 : 4'-disulphonamide, m.p. 132-134°
2. Diphenylamin-4 : 4'-di(N-phenyl)-disulphonamide, m.p. 170°c
3. Diphenylamin-4 : 4'-di(N-*o*-tolyl)-disulphonamide, m.p. 210°c
4. Diphenylamin-4 : 4'-di(N-*m*-tolyl)-disulphonamide, m.p. 205°c
5. Diphenylamin-4 : 4'-di(N-*p*-tolyl)-disulphonamide, m.p. 240°c
6. Diphenylamin-di(N-*o*-xylyl)-disulphonamide, m.p. 230°c
7. Diphenylamin-di(N-*m*-xylyl)-disulphonamide, m.p. 175°c
8. Diphenylamin-di(N-*p*-xylyl)-disulphonamide, m.p. 220°c
9. Diphenylamin-di(N-*o*-methoxyphenyl)-disulphonamide, m.p. 230°c.

91. Schiff's bases of 4-nitro-4'-aminodiphenylsulphone and their reduction products.

MIRCHANDANI PREM, B. H. IYER and P. C. GUHA, Bangalore.

Marshal, Litchfield and White (*J. Pharm. and Therap.*, 1940, 69, 89), have found that though 4 : 4'-diaminodiphenylsulphone is ten times more active than sulphanilamide, it is much more toxic. Recently three derivatives of this compound, *viz.*, the disodiumformaldehydesulphoxylate ('Diasone'), the diposphorylated derivative and the disodium-salt of the N : N'-didextrosulphonate ('Promin') have been found to produce evident inhibition of the development of experimental tuberculosis in guinea pigs (Callomon and Loraine Groskin, *Amer. Rev. Tuber.*, 1943, 47, 97. Smith, Emmert and Stohlman, *Amer. Rev. Tuber.*, 1943, 48, 32).

In an endeavour to find a drug similar in activity to 4 : 4'-diaminodiphenylsulphone but less toxic, a systematic investigation of a number of allied compounds has been started.

In the present paper the 4-nitro-4'-arylidenoaminodiphenylsulphones obtained by the condensation of 4-nitro-4'-aminodiphenylsulphone with benzaldehyde, salicylaldehyde, *ortho*-methoxybenzaldehyde, *para*-methoxybenzaldehyde and cinnamic aldehyde and their reduction products are described. Yields in the condensation reactions are quantitative, while in the reduction experiments about 60% of the theory.

92. Some N¹- and N⁴-alkylene-bis-sulphanilamides.

H. L. BAMI, B. H. IYER and P. C. GUHA, Bangalore.

With a view to making a systematic study of bis-sulphanilamides linked at N¹- and N⁴-positions through alkylene chains of varying length, a number of new compounds has been prepared.

By the action of the corresponding alkylene dibromide on the potassium salt of *p*-acetaminobenzenesulphonamide, the N^1 -substituted methylene-bis-, (m. p. 296°) ethylene-bis-, (m.p. 228-229°); trimethylene-bis-, (m.p. 170°); tetramethylene-bis-, (m.p. 150°); and penta-methylene-bis-, (m.p. 142°) sulphanilamides have been prepared.

By the action of the corresponding alkylene dibromide on sulphanilamide the N^4 -substituted methylene-bis-, (m.p. 196°); ethylene-bis-, (m.p. 294°); trimethylene-bis-, (m.p. 180°); tetramethylene-bis-, (m.p. 138°) and pentamethylene-bis-, (m.p. 155°) sulphanilamides have been prepared.

93. N^1 -Substituted sulphonamide derivatives of heterocyclic dicarboxylic acids.

B. C. JAIN, B. H. IYER and P. C. GUHA, Bangalore.

The paper details the preparation of the following seven N^1 -derivatives of sulphanilamides :

no.	name of the compounds formed	m.p.
I	2-Carboxy-furan-5-carbo- N^1 -acetylsulphanilamide	230°
II	<i>N</i> - <i>p</i> -sulphonamidophenyl-4-(<i>p</i> -aminophenylsulpho- nimino)-chelidamic acid	163°
III	<i>N</i> - <i>p</i> -sulphonamidophenyl-4-(<i>p</i> -aminophenylsulpho- nimino-1 : 4-dihydropyridino	210°(decomp.)
IV	Pyridine-2 : 3-dicarbo- N^1 -diacetsulphanilamide	308°
V	<i>N</i> (N^1 -sulphanilyl)-dihydrocollidino-dicarboxylic acid	above 300°(decomp.)
VI	<i>N</i> (N^1 -acetsulphanilyl)-chelidamic acid	227°(decomp.)
VII	<i>N</i> (N^1 -sulphanilyl)-chelidamic acid	255°(decomp.).

They have been obtained by the action of sulphanilamide, *p*-acetaminobenzene-sulphochloride or the potassium salt of *p*-acetaminobenzene-sulphonamide—as the case may be—on (a) furan-2 : 5-dicarboxylic acid, (b) chelidonic acid, (c) quinolinic acid, (d) dihydro-collidine dicarboxylic acid, and (e) chelidamic acid.

94. N^4 -Substituted sulphonamide derivatives of heterocyclic dicarboxylic acids.

B. C. JAIN, B. H. IYER and P. C. GUHA, Bangalore.

The paper deals with the preparation of the following twelve N^4 -derivatives of sulphanilamide :

no.	name of the compounds formed	m.p.
I	Pyridine-2-carboxy-3-carbo- N^4 -sulphanilamide	melts at 210°; solidifies and remelts at 260°
II	Pyridine-2 : 3-dicarbo- N^1 -monosulphanilamide	310-311°(decomp.)
III	Pyridine-2 : 3-dicarbo- N^4 -disulphanilamide	293°(decomp.)
IV	Dihydrocollidine-3 : 5-dicarbo- N^4 -disulphanilamide	285°(decomp.)
V	Collidine-3 : 5-dicarbo- N^4 -disulphanilamide	260°(decomp.)
VI	Pyridon-2 : 6-dicarbo- N^4 -disulphanilamide	322°(decomp.)
VII	Furan-2 : 5-dicarbo- N^4 -disulphanilamide	255°(decomp.)
VIII	3 : 4-Dihydroxyfuran-2 : 5-dicarbo- N^4 -disulphanila mide	at 260° and Shrinks decomp.
IX	3 : 4-Ethylenedioxyfuran-2 : 5-dicarbo- N^4 - disulphanilamide	Decomposes above 275°
X	1 : 4-Endoxycyclohexano-2 : 3-dimethyl-2 : 3- dicarbo- N^4 -sulphanilamide	234°
XI	3 : 4-Dihydroxythieno-2 : 5-dicarbo- N^4 -disulphani- lamide	Decomposes
XII	3 : 4-Ethylenedioxythieno-2 : 5-dicarbo- N^4 - disulphanilamide	Decomposes

They have been obtained by the action of sulphanilamide on (a) quinolinic acid, (b) diethyldihydrocollidine dicarboxylate, (c) collidine dicarboxylic acid, (d) chelidonic acid, (e) chelidamic acid, (f) furan-dicarboxylic acid, (g) oxalodiglycollic ester, (h) diethyl-furo-3 : 4-*p*-dioxano-2 : 5-dicarboxylate, (i) cantharidin, (j) thiodiglycollic ester and (k) diethyl-thieno-3 : 4-*p*-dioxano-2 : 5-dicarboxylic ester.

95. N¹- and N⁴- substituted sulphanilamides: Part I. Schiff's bases of sulphapyridine and sulphathiazole.

K. R. DORASWAMY and P. C. GUHA, Bangalore.

The Schiff's bases of sulphanilamide have been reported to be active by Galliot and Mayer (*Compt. rend. Soc. Biol.*, 1936, 121, 1082). Kolloff and Hunter (*J. Amer. Chem. Soc.*, 1940, 62, 158) reported that the Schiff's bases of sulphanilamide and sulphapyridine were active and also that they were much less toxic. To study the therapeutic potencies and toxic effects of the Schiff's bases of the two well reputed drugs of the sulphanilamide series viz. sulpha-pyridine and sulpha-thiazole, the following Schiff's bases have been synthesised and are being pharmacologically tested.:

The Schiff's bases of sulphathiazole from (i) benzaldehyde, (ii) anisaldehyde, (iii) vanillin, (iv) veratraldehyde, (v) cinnamaldehyde, (vi) furfuraldehyde, (vii) *m*-nitrobenzaldehyde, (viii) *m*-chlorobenzaldehyde, and (ix) phenylacetaldehyde, melted respectively at 202°, 160°, 245°, 138°, 260°, 210° (charring), 231°, 124° and 164°. The Schiff's bases of sulpha-pyridine with the same aldehydes melted at 240°, 205°, 146–147°, 210°, 210°, 214°, 254°, 101° and 100°(decomp.), respectively.

96. N¹- and N⁴-substituted sulphanilamides: Part II. Acyclic acyl derivatives of sulphathiazole and sulphapyridine.

K. R. DORASWAMY and P. C. GUHA, Bangalore.

Varying views have been expressed by different workers on the therapeutic effect of the acyl derivatives of sulphanilamide. With a view to making a systematic study of N⁴-acyclic acyl derivatives of sulphapyridine and sulphathiazole, the following acyclic acyl derivatives have been prepared, and are being pharmacologically tested. All the acyl derivatives except the formyl derivatives were obtained by the corresponding acid chloride on sulphapyridine or sulphathiazole. The formyl derivative was obtained by the action of ethyl formate on sulphathiazole or sulphapyridine.

The acyclic acyl derivatives of sulphathiazole from (i) formic, (ii) acetic, (iii) propionic, (iv) butyric, (v) isovaleric, (vi) caprylic, (vii) nonylic, and (viii) capric acids melted respectively at 215°, 256°, 245°, 250°, 190°, 214°, 189° and 142°. The acyclic acyl derivatives of sulphapyridine from the same acids melted respectively at 205°, 225°, 217°, 165°, 191–192°, 210°, 186° and 160°.

97. Parachor of fused ring structure: Parachor of *Bicyclo*-(2:2:2)-octane and *Bicyclo*-(3:2:2)-nonane derivatives.

P. C. GUHA and S. C. BHATTACHARYYA, Bangalore.

Determination of parachor has been widely used for elucidating the structure of many organic compounds. But little information is available about the parachor of bridged ring compounds containing six-, and seven-membered rings. The parachors of two such compounds have been determined by the bubble-pressure method in nitrobenzene solution. In both these compounds the experimentally determined parachors show a negative anomaly of about 4.5 units, indicating thereby that the rings are in a strainless condition.

98. N¹- and N⁴-substituted sulphanilamides: Part III. *Isocyclic* acyl derivatives of sulphathiazole and sulphapyridine.

K. R. DORASWAMY and P. C. GUHA, Bangalore.

Although much work has been done on the study of the N⁴-acyclic acyl derivatives, no systematic study has been made on the preparation and study of the therapeutic properties of N⁴-isocyclic acyl derivatives of sulphanilamide. The following N⁴-isocyclic acyl derivatives of sulphathiazole and sulphapyridine have been synthesised, and they are being pharmacologically tested. The acyl derivatives were prepared by the action of the appropriate acid chloride on sulphathiazole or sulphapyridine in aqueous alkaline solution.

The *isocyclic* acyl derivatives of sulphathiazole from (i) benzoic, (ii) *p*-chlorobenzoic, (iii) *p*-bromobenzoic, (iv) *p*-nitrobenzoic, (v) *p*-methoxybenzoic, (vi) cinnamic, (vii) phenylacetic, and (viii) *p*-toluic acids, melted at 250–51°, 240°, 203°, 245°, 185–86°, 253°, 143–45°, and 265° respectively. The *isocyclic* acyl derivatives of sulphapyridine from the same acids melted respectively at 245–46°, 238°, 215°, 258°, 165–66°, 235°, 189°, and 197–198°.

99. N¹- and N⁴-substituted sulphanilamides: Part IV. N⁴-Sulphonyl derivatives of sulphathiazole and sulphapyridine.

K. R. DORASWAMY and P. C. GUHA, Bangalore.

Crossley, Northey, *et al* (*J. Amer. Chem. Soc.*, 1938, 60, 2222) and Sprague, McBurney, *et al* (*J. Amer. Chem. Soc.*, 1940, 62, 1714) have synthesised N⁴-sulphonyl-sulphanilamides and they have found the introduction of a sulphonyl group into the N⁴-position markedly reduces the activity, and at the same time toxicity is much reduced. However, the introduction of sulphanilyl group (NH₂-C₆H₄SO₂-) increases the activity. To study the effect of the introduction of some aryl sulphonic groups into the N⁴-nitrogen of sulphathiazole and sulphapyridine, the following N⁴-sulphonyl derivatives of these two well reputed drugs have been synthesised by the action of the respectively aryl sulphonyl chlorides on sulphathiazole or sulphapyridine. The sulphanilyl derivatives were obtained by the hydrolysis of the corresponding aceto-sulphanilyl derivatives.

The sulphonyl derivatives of sulphathiazole from benzeno-sulphonic, toluene-sulphonic, *p*-acetaminobenzene-sulphonic, *p*-aminobenzene-sulphonic and *m*-nitrobenzenesulphonic acids melted at 189°, 172°, 128-30°, 210° and 175° respectively. The sulphonyl derivatives of sulphapyridine from the same sulphonic acids melted at 230°, 160°, 145-46°, 236-38°, and 185° respectively.

100. N¹- and N⁴-Substituted sulphanilamides: Part V. Azo-dyes derived from sulphathiazole and sulphapyridine.

K. R. DORASWAMY and P. C. GUHA, Bangalore.

Domagk (*Deut. Med. Wochschr*, 1935, 61, 250, 929) discovered the antistreptococcal property of "Prontosil", an azo-dye derived from sulphanilamide and later Trefouels, Nitti (*Comp. rend. Soc. Biol.*, 1935, 120, 756) found that it was the sulphanilamide part of the molecule that was responsible for this property. However, some azo-dyes derived from diazotised sulphanilamide with resorcinol, 3 : 5-diaminobenzoic acid, etc. have been reported to be more active than sulphanilamide itself.

In this paper, sulphathiazole and sulphapyridine have each been diazotised and coupled with phenol, *p*-cresol, resorcinol, resorcinol monomethyl ether, 1 : 2 : 5-xenol, salicylic acid, β -naphthol, and α -naphthol; dimethylaniline, *m*-phenylene-diamine, anthranilic acid, β -naphthylamine, and naphthionic acid, giving rise to 26 azo-dyes in all. These azo-dyes are generally red in colour (various shades of red), without definite melting points or crystalline structure. The results of their pharmacological examination are eagerly awaited.

101. N¹-Sulphanilamide derivatives of thiurets.

P. C. GUHA and S. SWAMINATHAN, Bangalore.

4-Acetaminobenzene sulphochloride has been condensed with mono and di-substituted thiurets. The compounds obtained from phenyl, *p*-tolyl, *o*-tolyl, *o*-methoxyphenyl, α -naphthyl, β -naphthyl, *o*-ethoxy-phenyl, phenyl-methyl and phenyl-ethyl thiurets melt respectively at 174°, 168°, 164°, 153°, 162°, 179°, above 300°, 217°, 189°, 191°, and 183°. Xanthone hydride has also been condensed with acetaminobenzenesulphochloride. The condensation product melts at 197°. The acetyl derivatives when subjected to hydrolysis got completely decomposed.

Work on the action of 4-acetaminobenzenesulphochloride on alkyl-thiol derivatives of substituted dithio-thiurets is in progress.

102. Meyer's synthesis of pyridines from aminoacrylo-nitriles. Verification in the light of Gastaldi's objections.

N. PALIT, Patna.

Meyer has developed a method for the synthesis of pyridines. β -Amino- β -methylacrylonitrile was condensed with benzylideneacetophenone in presence of NaOEt to yield 3-cyano-2 : 4-diphenyl-6-methylpyridine. The cyano group was hydrolysed with conc. HCl at 260° to the carboxy derivative (I) which when heated with lime lost CO₂ and gave 2 : 4-diphenyl-6-methylpyridine (II) m.p. 158°. (I) on oxidation with permanganate gave 2 : 4-diphenylpyridino-5 : 6-dicarboxylic acid (III) m.p. 185° (*Chem. Zentr.* 1908, II, 594). Gastaldi has thrown considerable doubt on this reaction. He claims to have obtained (II) from acetophenone or dyponone by the action of acetic anhydride in presence of ferric chloride and treating the resulting pyrylium salt with ammonia (*Gazzetta* 1922, 52, 169, 305) and found it to be different from (II) m.p.

73°. To settle this controversial issue an unambiguous synthesis of (II) has been undertaken and while it is in progress enough evidence has been collected to show that Meyer's mode of representing the reaction is not erroneous.

In the first instance β -amino- β -phenylacrylonitrile was condensed with O-ethylether of dibenzoylmethane, a substance which can hardly be expected to react in any abnormal way. The product formed was identical with 3-cyano-*sym*-triphenylpyridine obtained by Meyer from the same aminonitrile and benzylideneacetophenone (*loc. cit.*). This reaction can hardly be regarded capable of taking any other course. Moreover, this cyanopyridine derivative on hydrolysis and removal of CO₂ gave *sym*-triphenylpyridine identical with that previously obtained by Newman from the monoxime of benzalacetophenone by passing dry HCl in its benzene solution (*Ann.* 302, 240).

In the second instance (III) has now been obtained by the oxidation of 2 : 4-diphenyl-7-oxyquinoline (m.p. 273°) which has been synthesised by boiling meta-amidophenol and benzylideneacetophenone in alcoholic solution with a trace of alkali. The dicarboxy acid so obtained agrees with Meyer's compound (III). This, therefore, establishes the correctness of Meyer's reaction.

103. O-Substituted diphenyls. A new synthesis of phenanthrene.

S. A. FASEEH and S. H. ZAHEER, Lucknow.

In our paper submitted last year (*Proc. 32nd Ind. Sc. Cong. 1946, Part III, p. 141*) we described the preparation of *o*-phenyl cinnamic acid. Starting with this acid the preparation of the *o*-Phenyl dichloro-cinnamic acid, *o*-phenyl-*w*-chloro-styrene and the utilisation of the latter compound in an elegant synthesis of phenanthrene has already been reported by us elsewhere (*J. Ind. Chem. Soc.* 1945, 6, in press).

On keeping *o*-phenyl cinnamic acid for twenty-four hours in a solution of bromine in chloroform the corresponding dibromo acid has also now been prepared by us, as colourless crystals in almost theoretical yield, m.p. 171°. The dibromo compound loses hydrobromic acid far more readily than the corresponding dichloro acid. It is necessary only to keep it at the room temperature with an aqueous solution of sodium carbonate, when *o*-phenyl-*w*-bromo-styrene, b.p. 167°/5 mm, begins to separate as an oil within half an hour. The reaction is nearly complete in twenty-four hours. This substance after purification by distillation under reduced pressure also gave phenanthrene by the further loss of a molecule of hydrobromic acid on treatment with anhydrous aluminium chloride. The yield is nearly 40 percent.

Here also, in addition to phenanthrene, a considerable quantity of a brown plastic substance is obtained whose nature has not yet been closely investigated. If this reaction takes place with the removal of hydrobromic acid from the side chain no ring closure would occur and *o*-diphenyl acetylene would be formed. The formation of this compound, however, is unlikely as halogen derivatives of ethylenic compounds are usually found not to yield the acetylenic compounds by the loss of a molecule of hydro-halogen acids with the agency of aluminium chloride. This compound has not been isolated by us. We suspect that the plastic substance mentioned above is a polymerised product.

104. Hydrolysis of nitriles : Preparation of the acids.

G. G. MUJUMDAR, K. K. DOLE and D. D. KARVE, Poona.

In continuation of the previous work, on the preparation of the organic acids by the hydrolysis of the nitriles, the two-step method, mentioned in the earlier communication, is extended to include the following nitriles : Benzo-, *p*-chlorbenzo-, *p*-brombenzo-, *o*-tolu-, *m*-tolu-, *p*-tolu-, *m*-nitro-, *p*-nitro-, phenylaceto-, *p*-nitrophenylaceto-, and α -naphtho-nitrile.

Good results have been obtained both as regards the yield of the acid and the time required for the hydrolyses. In the case of α -naphthoic acid, it was prepared with ease in less than 2½ hours with a yield of over 90%, whereas the best among the present methods available require much longer time.

105. Synthesis of cyanine dyes by the condensation of *p*-diethylamino-benzaldehyde with appropriate heterocyclic compounds. Part II.

M. Q. DOJA and J. C. BANERJEE, Patna.

In view of the fact that the cyanine dyes of the thiazole series are commercially valuable sensitizers, five new dyestuffs of this group have been synthesised by the condensation of *p*-diethylamino-benzaldehyde with the methiodides of 2 : 4-dimethyl-thiazole, 2-methyl-4-phenyl-thiazole, 2-methyl-benzothiazole, 2-methyl- α -naphthathiazole and 2-methyl- β -naphthathiazole. The chemical, dyeing, optical and photographic properties of these compounds have been examined and recorded. A compari-

son has also been made with the corresponding dimethylamino-derivatives prepared by the condensation of *p*-dimethylamino-benzaldehyde with these same heterocyclic ammonium compounds. The preparation of some of the "intermediates" has also been described.

106. Chemical examination of the seeds of *Citrullus colocynthis*, Schrader. (N. O. Cucurbitaceae).

R. C. BADAMI and R. L. ALIMCHANDANI, Dharwar.

In continuation of our work on the above subject published in the "Proceedings of the Thirty-Second Indian Science Congress", the alcoholic extract of the seeds of *Citrullus Colocynthis* was extracted successively with petrol-ether, ethyl-ether, chloroform, ethyl acetate and ethyl alcohol.

The alcohol-soluble petrol-ether extract did not give any test for the presence of the bitter principle. A solid (ether-insoluble) was isolated which gave all the tests of a phytosterol. From the alcohol-insoluble petrol-ether extract, two solids were obtained and their melting points were determined. The solid from the ether-insoluble portion gave all the characteristic tests of a phytosterol, whereas that from the ether-soluble portion did not give any test for a phytosterol.

From the ether-extract of the alcoholic extract, the bitter principle was isolated. It gave positive tests for the presence of an alkaloid. Further work is in progress.

107. Halogenation. Part XXXVI. Iodination of aromatic nitro-hydrocarbons.

P. S. VARMA and T. S. SIVASWAMI, Benares.

It is generally known that the presence of a nitro group retards the entrance of halogens in the aromatic nucleus and the difficulty becomes more pronounced in the case of iodine. This explains why all the iodonitro-hydrocarbons described in literature have been prepared mainly from nitro-amino compounds by Sandmeyer's reaction. Applying the methods developed in this laboratory nitro-hydrocarbons have been iodinated using iodine and a mixture of concentrated nitric and sulphuric acids in some cases, and sodium nitrite and fuming sulphuric acid in some other cases. Many iodonitro-hydrocarbons have been obtained.

Nitrobenzene thus gives *m*-iodo-nitro-benzene, *o*-nitro-*o*-uene 4-iodo-2-nitro-toluene; *m*-nitro-toluene 6-iodo-nitro-toluene, and 5-iodo-3-nitro-toluene *p*-nitro-toluene 2-iodo-4-nitro-toluene. 2-Nitro-*p*-xylene gives an iodo-nitro compound melting at 99°. Iodination of other mono-and dinitro-compounds is in progress.

108. Halogenation. Part XXXVII. Halogen derivatives of cumene.

P. S. VARMA and M. SANTHAPPA, Benares.

p-Iodo-isopropyl benzene has been obtained by the method worked out in this laboratory by heating in presence of a mixture of nitric and fuming sulphuric acids. From *p*-iodo derivative, *p*-iododichloride, *p*-iodoso- and *p*-iodoxy derivatives have been obtained. *p*-Iodo-isopropyl benzene has been further iodinated under certain definite conditions to get a diiodo-isopropyl benzene and nitrated to obtain a dinitro-diiodo-derivative, melting at 180°.

109. Halogenation. Part XXXVIII. Halogen derivatives of naphthalene.

P. S. VARMA and N. L. SETTY, Benares.

α -Bromo-naphthalene has been iodinated to obtain 1-bromo-4-iodo-naphthalene and α -nitronaphthalene iodinated to get 1-nitro-8-iodo-naphthalene, prepared for the first time by direct iodination. 1:4-Dibromonaphthalene yields on nitration 1:4-dibromo-8-nitro-naphthalene, a compound that can also be obtained by brominating α -nitro-naphthalene. α -Iodo-naphthalene on nitration gives 1-iodo-4-nitro-, and 1-iodo-8-nitro-naphthalene, prepared before by indirect methods only.

110. Syntheses of 2-, 3- and 4- methyl derivatives of 10-chloro-phenthiazine.

P. S. VARMA, and S. A. SUBRAMANIAN, Benares.

10-Chloro-phenthiazine has been synthesised by Roberts and Turner (J.C.S., 1925, 2008) from thiophenol and *o*-chloro-nitro-phenol. Using the same method attempts are being made to prepare the three isomeric methyl derivatives using *o*-, *m*-, and *p*-

thiocresols. *o*-, *m*-, and *p*-Thiocresols are condensed with *o*-chloronitrobenzene in presence of copper powder and potassium hydroxide (Manthner, *Ber.*, 1906, 39, 3597; Varma, Venkatraman and Malani, *J.I.C.S.*, 1942, 354-356, to yield 2-nitro-2'-methyl, 2-nitro-3'-methyl and 2-nitro-4'-methyl diphenyl sulphides. These nitro compounds are then reduced by iron and hydrochloric acid to yield 2-amino-2'-methyl (m.p. 37°) 2-amino-3'-methyl (low melting solid) and 2-amino-4'-methyl (m.p. 82°) diphenyl sulphides. The amine hydrochlorides when subjected to Bart's reaction give the corresponding arsinic acids. The arsinic acids are being reduced and converted into the arsenous chlorides which when heated at 200° in an atmosphere of CO, for about 20 hours are expected to yield by pyrolysis 4-methyl-, 1-or 3-methyl,—and 2-methyl-10-chloro-phenarsazine respectively.

111. Resolution of $\alpha\gamma$ -diphenyl glutaconic acid.

G. M. KELKAR, N. L. PHALNIKAR and B. V. BHIDE, Poona.

The resolution of $\alpha\gamma$ -dimethyl glutaconic acid (the first open chain acid resolved) has disproved the 'normal' symmetrical structure of glutaconic acids (McCombs, Packer and Thorpe, *J. Chem. Soc.*, 1931, 547.). This has been now further supported by the resolution of $\alpha\gamma$ -diphenyl glutaconic acid.

$\alpha\gamma$ -Diphenyl glutaconic acid (Phalnikar and Nargund, *J. Univ. Bom.*, 1938, 7, iii, 203,) has been now resolved into the *d* and *l* forms through its strychnine salt. The acid does not racemise even on boiling with hydrochloric acid or with sodium hydroxide for 4 hours.

112. A new synthesis of phenacetin.

S. SWAMINATHAN, Bangalore.

A new method of synthesising the well-known antipyretic drug phenacetin has been devised. Phenetole, obtained by the action of ethyl bromide on phenol, is reacted with acetyl chloride in presence of aluminium chloride to produce *p*-acetyl phenetole the oxime of which on treatment with phosphorous pentachloride in ether gives phenacetin. The yield at every stage is almost quantitative, except at the last stage where it is 80 per cent.

The same method has been used successfully in the preparation of 1-acetamino-4-methoxy-naphthalene.

113. Chemical examination of the seeds of *Mucuna pruri*t, Hook., Syn. *Mucuna pruri*ens. Bak.

P. V. NAIR and K. S. MADHAVAN PILLAI, Trivandrum.

The petrol-ether extract of the seeds of *Mucuna pruri*t, Hook, syn., *Mucuna pruri*ens, Bak., (N.O. Papilionaceae) has yielded 5.9 per cent of a fatty material which on hydrolysis gave stearic, palmitic, linoleic and oleic acids. The ash value of the seeds gave indications of the high content of phospho-compounds (33% as P₂O₅) and sulpho-compounds (16% as sulphate). Manganese is present to the extent of 0.72 per cent. The phosphorus was found mainly present as lecithin, the sulphur as glutathione and manganese as mangano-proteins. The seeds of the plant are used in Ayurvedic pharmacy as an alexipharmic, laxative, aphrodisiac and general tonic.

114. Chemical examination of the roots of *Cyclea burmanni*, M.

P. V. NAIR and (Miss) P. SARADAMMA, Trivandrum.

The plant belongs to the N.O. Menispermaceae and its powdered roots are used in Ayurvedic medicine in the treatment of phlegmatic complaints, internal spasms etc. The petrol-ether extract of the dried roots furnished 8% of its weight of a reddish yellow oil which remains solid at room temperature but melts at slightly elevated temperatures. The defatted roots on extraction with alcohol yielded three crystalline substances, m.p. 235°, 218° and 155°. The substance melting at 235° is a cyclo-hexanol (quercitol ?) while the other two have furnished indications of alkaloidal character.

115. Coumarins from 4-methoxy-2-hydroxy-benzaldehyde and its derivatives.

S. VENKATA RAO and H. SUBBA JOIS, Bangalore.

Starting with 4-methoxy-2-hydroxy-benzaldehyde by condensation with anhydrous sodium acetate in presence of acetic anhydride and a few drops of pyridine, 7-methoxy

coumarin has been prepared. Starting with 5-chloro-4-methoxy-2-hydroxy-benzaldehyde by a similar process 6-chloro-7-methoxy coumarin has been prepared. 6-Nitro-7-methoxy coumarin is also prepared by a similar method from 5-nitro-4-methoxy-2-hydroxy-benzaldehyde. These coumarins are opened up with methyl sulphate and alkalis to dimethoxy cinnamic acid and its derivatives.

116. The interaction of starch and iodine.

S. MUKHERJEE and S. BHATTACHARYYA, Calcutta.

Titration of amylose, potato starch and shoti starch, both potentiometric and using a photo-electric colorimeter, show that the latter can be adopted as a method for the estimation of amylose in starches. Changes in concentrations of KI alter the positions of end-points as well as the shapes of the titration curves obtained with photo-electric colorimeter. Increase in the concentration of KI increases the ratio of starch to iodine at the end-points. This ratio is higher for whole starch than for amylose.

Isolation and analysis of the iodine-complexes of amylose and potato and shoti starches show the same ratio of starch to iodine in all of them-3.5 glucose residues for each atom of iodine. This tends to indicate that both amylose and the other constituent, amylopectin, of these starches can form complexes with iodine in the same molecular proportions under the conditions of the experiment.

117. Quinoline-arsonic acids.

T. N. GHOSH and A. C. ROY, Calcutta.

The pronounced amoebicidal property of chiniofon and of phenylarsonic acid derivatives such as, carbarsone and stovarsol, is well known. In the search for an ideal amoebicide it has been thought worth while to synthesise 7-iodo-8-hydroxyquinoline-5-arsonic acid, which is structurally related to chiniofon.

Few quinoline-arsonic acid derivatives are known in literature and they have been prepared by Bart's reaction which is rather tedious and generally gives poor yield of the products. By applying the method of Dobner and Miller, 2-methyl-8-hydroxyquinoline-5-arsonic acid (I) has now been synthesised by reacting 3-amino-4-hydroxyphenylarsonic acid with paraldehyde in presence of concentrated hydrochloric acid. The compound (I) gives the 7-iodo derivative (II), which is structurally related to chiniofon. Similarly, by reacting *p*-arsanilic acid with paraldehyde under identical conditions, 2-methylquinoline-6-arsonic acid (III) has now been obtained.

118. Schiff's bases from sodium arsanilate.

U. P. BASU and S. C. CHAUDHURY, Calcutta.

Sodium arsanilate is a valuable drug in arsenic therapy and owing to the presence of a free amino grouping it gives rise to many toxic symptoms. As such its various other derivatives obtained by substituting the amino hydrogen, are being largely used in medicine. These compounds such as Carbarsone, Tryparsamide have again certain other draw-backs. It is generally agreed that the *p*-amino grouping slowly undergoes oxidation in the system and gives rise to the characteristic therapeutic as well as toxic action. In the above derivatives the amino group is more rigidly substituted and as such it was considered to be of interest to study some other derivatives of sodium arsanilate whence its amino group may be slowly liberated to exert the characteristic pharmacological action of the mother compound.

With this idea in view various aldehydes, like formaldehyde, benzaldehyde, anisaldehyde, salicyl aldehyde, cinnamic aldehyde and dimethylaminobenzaldehyde, have been condensed with sodium arsanilate in presence of alcohol. The condensation products (the Schiff's bases) are mostly crystalline substances and readily undergo reaction with sodium bisulphite to offer products readily soluble in water. These compounds are now being physiologically tested. Already the product from cinnamic aldehyde has been noticed to be practically free from any toxicity. Work is in progress.

119. Citrinin.

R. G. CHITRE, T. S. GORE, T. B. PANSE and K. VENKATARAMAN, Bombay.

A crystalline yellow substance isolated by Manohar (*Ind. Med. Rec.*, 1944, 65, No.1) as a metabolite of a mould of the *Penicillium* group, provisionally identified as *Penicillium spinulosum*, stated to have marked bacteriostatic activity and named 'Notalin', has been identified as citrinin, the metabolite of *Penicillium citrinum* Thom (Hetherington and Raistrick, *Phil. Trans. Roy. Soc.*, 1931, 220, 209).

Citrinin is a phenol carboxylic acid, and Coyne, Raistrick and Robinson (*Phil. Tran. Roy. Soc.*, 1931, 220, 297) have suggested a structure for citrinin in which all the positions of the benzene ring are occupied. We have now observed that citrinin couples readily with diazotised aniline, 2,5-dichloraniline and sulphanilamide, to yield the corresponding azo dyes. Analysis indicated no displacement of any of the groups in the citrinin molecule during coupling. The azo dye from dichloraniline titrated correctly for a monocarboxylic acid. In view of the quinonoid character of citrinin, other possibilities for its interaction with diazo salts have been considered, but it would appear that coupling takes place in the normal manner.

While Raistrick and Smith (*Chem. and Ind.*, 1941, 60, 829) in contrast to Manohar, have been careful in stating that no claims were made regarding the value of citrinin as a chemotherapeutic agent, pending extensive pharmacological tests, citrinin remains of unusual interest as an antibacterial substance on account of its stability and the high yields in which it can be obtained. Raistrick and collaborators were able to isolate 2 g. of citrinin per litre of metabolism solution; and the yield using Manohar's organism was 0.35 g. per litre.

120. Sulphuryl chloride : a new condensing agent for Pechmann reaction : Condensation of resorcin with acetone dicarboxylic acid. Separation of *trans*, β -2 : 4-dihydroxyphenyl glutaconic acid.

V. M. DIXIT and L. N. MULAY, Dharwar.

Resorcin was condensed with acetone dicarboxylic acid using sulphuryl chloride as the condensing agent. Two acids (A) and (B) were separated from the condensation product by careful fractional crystallisation, in addition to a non-acidic substance (C). The acid (A) was identified as 7-hydroxy-coumarin-4-acetic acid. The acid (B) titrated as a dibasic acid and was considered to be the *trans* isomer of β -2 : 4-dihydroxyphenyl glutaconic acid, yield 40%, light rhombic plates from very dilute alcohol, m.p. 195-197° (decomp); Eq. wt. 125. It gives calcium, barium, strontium and lead salts which are insoluble in cold water.

The structure of *trans*- β -2 : 4-dihydroxy-phenylglutaconic acid for the acid (B) has been confirmed by (i) converting the acid into the acetyl derivative of its anhydride (ii) converting the acid into the diethyl ester, the acetyl derivative of which was identical with that obtained by boiling the acetyl derivative of the anhydride with ethyl alcohol, (iii) converting the acid into the *cis*-isomer which immediately changes to 7-hydroxy-coumarin-4-acetic acid, (iv) by decarboxylating the acid with HI and identifying the product with that obtained by treating β -2 : 4-dimethoxy-phenyl glutaconic acid with HI.

The non-acidic product (C) from the original condensation was found identical with the dilactone of $\beta\beta$ -di-(2: 4-dihydroxy-phenyl) glutaric acid already obtained by condensing resorcin with acetone dicarboxylic acid in the presence of other condensing agents like $AlCl_3$, $POCl_3$, P_2O_5 and $SOCl_2$.

Further work is in progress.

121. Phosphorous oxychloride : A reagent for the Pechmann condensation of phenols with acetone dicarboxylic acid.

V. M. DIXIT and A. M. KANKUDTI, Dharwar.

Acetone dicarboxylic acid was condensed with cresols and naphthols in the presence of phosphorous oxychloride and the following results were obtained :—

1. *m*-Cresol—The condensation product was a mixture of (i) an acid and (ii) a non-acidic substance. The acid, after separation, was identified as 7-methyl coumarin-4-acetic acid. The non-acidic substance appeared to be the dilactone of $\beta\beta$ -di-(2-hydroxy-4-methyl)-phenyl glutaric acid. This dilactone was independently synthesised by condensing *m*-cresol with 7-methyl coumarin-4-acetic acid.
2. *p*-Cresol :—This also gave an acid, and a non-acidic compound. The acid, was identified as 6-methyl coumarin-4-acetic acid; the non-acid by analogy is considered to be the dilactone of $\beta\beta$ -di-(2-hydroxy-5-methyl)-phenyl glutaric acid.
3. α -Naphthol :—This did not give any non-acidic product. The acid was identified as the corresponding coumarin-4-acetic acid described by Dey (*J. C. S.* 1915, 1606).
4. β -Naphthol :—This gave both an acid and a non-acidic substance. The acid was identified as the corresponding coumarin-4-acetic acid already described by Dey (*loc. cit.*). The non-acid is considered to be the dilactone of $\beta\beta$ -di-(2-hydroxynaphthyl) glutaric acid.

Further investigation of the non-acidic compounds is in progress.

122. Synthesis of 8-hydroxyquinoline and some of its therapeutic derivatives.

S. F. BOYCE, G. V. JADHAV and R. C. SHAH, Bombay.

8-Hydroxyquinoline has been prepared by Skraup's synthesis starting from *o*-nitrophenol. Several improvements have been effected in the usual process.

5-Chloro-7-iodo-8-hydroxyquinoline (Vioform) has been prepared (1) by direct iodination of 5-chloro-8-hydroxyquinoline obtained from 2-amino-4-chloro-phenol by Skraup's synthesis or from 5-bromo-8-hydroxyquinoline and (2) also by the action of iodine trichloride on 8-hydroxyquinoline. An intensive study of the various steps involved in the synthesis has been made, which has resulted in improved yields.

The preparation of 7-iodo-5-sulphonic acid-8-hydroxyquinoline (Yatren) and 5 : 7-diiodo-8-hydroxyquinoline has also been studied.

123. Study of the action of chlorosulphonic acid on toluene.

A. B. KULKARNI, G. V. JADHAV and R. C. SHAH, Bombay.

The interaction of chlorosulphonic acid and toluene has been studied at various temperatures with different proportions and it has been observed that at higher temperatures along with the monosulphonyl chlorides di- and tri-sulphonyl chlorides are obtained. It is further observed that if instead of toluene, salts of sulphonic acids of toluene are used better yields of mono-sulphonyl chlorides are obtained. This fact along with the observations now made for the first time that toluene sulphonyl chlorides are decomposed by chlorosulphonic acid and sulphuric acid explains why such a large excess of chlorosulphonic acid is necessary to get better yields of sulphonyl chlorides.

124. Nitration of chromones. Part I. Nitration of 7-hydroxychromones.

G. V. JADHAV, A. M. MEHTA and R. C. SHAH, Bombay.

No systematic study of the nitration of chromones appears to have been made so far.

An attempt to study the nitration of 7-hydroxy-2-methylchromone, 7-hydroxyflavone and their methyl ethers has now been made and the constitutions of the resulting nitro derivatives established through their hydrolysis with alkaline reagents and the consequent isolation of known nitro derivatives of resorcinol and resacetophenone.

Thus mononitro derivatives of 7-hydroxy-2-methylchromone and 7-hydroxyflavone, which gave 2-nitroresorcinol on hydrolysis, have been assigned the structures 7-hydroxy-8-nitro-2-methylchromone and 7-hydroxy-8-nitroflavone respectively. Similarly the dinitro derivatives of the same compounds have been assigned the structures 7-hydroxy-6 : 8-dinitro-2-methylchromone and 7-hydroxy-6 : 8-dinitroflavone as both yielded 3 : 5-dinitroresacetophenone on hydrolysis with aqueous alkali.

The nitration of the methyl ethers of the 7-hydroxychromones gave the corresponding 6-nitro and 6 : 8-dinitro compounds which is shown by the fact that they were found to be identical with the methyl ethers of the nitro compounds described above.

125. Nitration of chromones. Part II. Nitration of 5-hydroxychromones.

G. V. JADHAV, A. M. MEHTA and R. C. SHAH, Bombay.

Nitration of 5-hydroxy-2-methylchromone, 5-hydroxyflavone and their methyl ethers has been systematically studied under different conditions and the mono and dinitro derivatives prepared.

On hydrolysis with aqueous and alcoholic alkali they yielded mono and dinitro derivatives of 2-acetylresorcinol or 7-resorcylic acid showing that either 6- or 8-nitro and 6 : 8-dinitro derivatives are formed.

It has also been observed that the methyl ether of 5-hydroxyflavone gives both the mono (6- and 8-) nitro derivatives, although one of them is obtained in a very poor yield.

Further work to establish their structures is in progress

126. Studies in Fries migration. Part I. Fries migration of esters of 7-hydroxy-4-methylcoumarin.

V. M. THAKOR and N. M. SHAH, Bombay.

A detailed study has been made of the Fries migration of 7-acetoxy and 7-benzoyloxy-4-methylcoumarin using different temperatures with different molecular proportions of aluminium chloride. It was observed that : (i) at least three mols. of alu-

minium chloride are necessary for migration; (ii) high temperature is necessary to effect the migration, low temperature gives only the deacylated product; (iii) solvent makes the reaction more smooth and improves the yield; (iv) benzoyl group requires higher temperature for migration than the acetyl group; (v) the migration mainly takes place to the '8' position giving 7-hydroxy-4-methyl-8-acetyl-or-8-benzoylcoumarin, with minute amount of the 6-acyl isomer in some cases. Under no conditions the 6-acyl isomer can be obtained as a major product.

The Fries transformation of the acetyl and benzoyl esters of 7-hydroxy-3-alkyl-4-methyl-6-ethylcoumarin (alkyl = methyl, ethyl, propyl or butyl) was studied to observe the influence of ethyl group in '6' and alkyl groups in '3' positions. Neither of them had any noticeable influence on the transformation which furnished 7-hydroxy-3-alkyl-4-methyl-6-ethyl-8-acetyl-or-8-benzoylcoumarin in good yield.

127. Studies in Fries migration. Part II. Synthesis of 2-benzoyl-4-ethyl-resorcinol.

V. M. THAKOR and N. M. SHAH, Bombay.

4-Ethylresorcinol was condensed with ethyl acetoacetate under Pechmann conditions to give 7-hydroxy-4-methyl-6-ethylcoumarin. Its benzoyl ester was made to undergo Fries transformation and the 7-hydroxy-4-methyl-6-ethyl-8-benzoylcoumarin, thus obtained, was hydrolysed by alkali to 2-benzoyl-4-ethylresorcinol. 2-Benzoyl-4-ethylresorcinol easily undergoes Pechmann condensation with ethyl acetoacetate to give 7-hydroxy-4-methyl-6-ethyl-8-benzoylcoumarin in good yield.

128. Bromination of compounds containing two aromatic nuclei.

G. V. JADHAV and MD. ASLAM, Bombay.

Aryl esters of *o*-, *m*-, *p*-, cresotic acids are brominated with varying amounts of bromine, when it is found that bromine first enters the acidic part of the molecule and then into the phenolic part in the case of *o*-, and *p*-cresotic acids. But in the case of *m*-cresotic acid it enters the acid part only to give the dibromo acid derivatives. Only when excess of bromine is used, tribromo derivatives with bromine in the phenolic part can be obtained in the case of *m*-cresotic acid. Phenyl, *o*-, *m*-, *p*-, cresyl, α , β -naphthyl and nitro-phenyl esters are worked out. The constitutions of these bromo derivatives have been proved by hydrolysis as well as by synthesis.

The same aryl esters of β -naphthoic acid are also similarly brominated where also bromine is found to enter the acidic part of the molecule.

129. Nitration of coumarin derivatives.

G. V. JADHAV and A. R. NAIK, Bombay.

Methyl 4-methyl-7-hydroxy-6-carboxylate and its methyl ether are nitrated under varying conditions, when mono- and dinitro derivatives are obtained. In the case of free acid, however, a mixture of nitro compounds with and without the carboxyl group is obtained.

The work has also been extended to 3:4-dimethyl-7-hydroxy and 4-methyl-7-hydroxy-8-acetyl-coumarins, when also different nitro derivatives are obtained according to the conditions of the reaction.

130. Reactivity of chalkones.

G. V. JADHAV and H. P. WANDREWALLA, Bombay.

2-Hydroxy-4-methoxy-acetophenone is condensed with *o*-methoxy-benzaldehyde, when 2-hydroxy-4-methoxy-phenyl-2'-methoxy styryl ketone is obtained. When this is brominated with different quantities of bromine, 2-hydroxy-4-methoxy-phenyl- α - β -dibromo-2'-methoxy-phenyl-ethyl ketone (1) and 2-hydroxy-4-methoxy-5-bromo-phenyl α - β -dibromo-2'-methoxy-5'-bromo-phenyl-ethyl ketone (2) are obtained. The reactivity of α , β bromine atoms is tested with (a) potassium iodide (b) pyridine (c) sodium hydroxide (d) sodium ethoxide and (e) potassium cyanide, when 2-hydroxy-4-methoxy-5-bromo-phenyl-2'-methoxy-5'-bromo-styryl ketone, 2-hydroxy-4-methoxy-5-bromo-phenyl- α -bromo-2'-methoxy-5'-bromo-styryl ketone, 5-bromo-6-methoxy-2'-methoxy-

5'-bromo-coumaranone (in the case of c and d) and 5-bromo-6-methoxy-2'-methoxy-5'-bromo-flavone are obtained respectively. The constitutions of these compounds are proved by preparing them by direct synthesis wherever possible or by the study of their characteristic properties.

The work is also extended to chalcones obtained by the condensation of *o*-methoxy-benzaldehyde with 2:4-dimethoxy-acetophenone, 4-benzyloxy-2-hydroxy-acetophenone and resacetophenone also.

131. Fixed oil from the seeds of *Entada scandens*.

A. N. POTI and K. RAMACHANDRAN NAIR, Trivandrum.

The seeds of *Entada Scandens* on extraction with light petroleum (50-60°) gave 12.2% of a pale yellow oil. The oil had the following physical and chemical constants:

Specific gravity	= 0.9143
Refractive Index	= 1.4523
Acid value	= 0.717
Saponification value	= 189.3
Iodine value (Wij's)	= 81
Acetyl value	= nil
Unsataponifiable matter	= 0.5 per cent

The fatty acids liberated from the oil have got a mean molecular weight of 299.1 and melted completely at 30°. On resolution it was found to contain 12.6% solid acids and 87.3% of liquid acids. The solid acids consisted of palmitic and lignoceric and with a small percentage of Stearic acid, while the liquid acids consisted of linolic and oleic acids.

132. Chemical examination of the bark of *Alangium lamarkii*. Isolation of an alkaloid.

S. DUTT, Delhi.

From the bark of *Alangium Lamarki*, a yellow alkaloid has been isolated having the molecular formula $C_{19}H_{25}O_5N$. The hydrochloride, sulphate, tartarate, oxalate, picrate and iodomethylate γ - have been obtained in a crystalline condition. The alkaloid has been found to be a tertiary base with an alcoholic hydroxy group, one methoxy group and one oxygen in a ring system.

133. A new process of esterification with water-insoluble alcohols. Esters of isooamyl alcohol.

S. DUTT, Delhi.

A new process of azeotropic esterification has been developed giving quantitative yields with theoretical proportions of water-insoluble alcohols and organic acids. In the present paper isooamyl alcohol has been quantitatively esterified with a large number of organic acids. The technique of the process is comparatively simple. Equimolecular proportions of alcohols and the acid are treated with benzene and the mixture distilled. Water and benzene pass over and are separated by an automatic separator, from which the benzene reenters the reaction vessel and the whole process is repeated over and over again. When the elimination of water stops the esterification is complete.

134. Metallic co-ordination compounds with isonitrosodiphenylthiobarbituric acid.

S. DUTT, Delhi.

Isonitrosodiphenylthiobarbituric acid has been found to give intensely coloured metallic derivatives some of which are true salts, but many of which are co-ordination compounds. It is interesting to note in this connection that the mother substance behaves like a polygenic dyestuff like alizarin giving differently coloured derivatives with different metals. No two colours are the same. Thus ferrous salt is deep indigo blue,

silver salt is emerald green, chromium salt is pink, lead salt is leather brown and so on. The salt can all be crystallised from aqueous acetone in glistening needles and prisms.

135. Synthesis of long-chain acids containing a system of conjugated double bonds.

P. C. MITTER and P. C. MUKHERJEE, Calcutta.

In a previous communication (Mitter and Gogoi, *Proc. Sc. Congress* 1942) it has been stated that the half-ester chloride of Δ^1 adipinic acid does not condense with zinc-n-butyl iodide to give the corresponding unsaturated keto-ester, the n-butyl-ethyl ester of Δ^1 adipinic acid being formed instead. It has now been found that cadmium n-butyl bromide gives the desired unsaturated keto-ester (semicarbazone, m.p. 235°) smoothly.

On reduction with aluminium isopropoxide followed by dehydration the substance is expected to give a deca-dienic acid with the system of conjugated double bonds in the same position as in the acid component of spilanthol.

136. Synthetical experiments in the steroids.

PHANINDEA CHANDRA DUTTA, Calcutta.

In continuation of the investigations described previously (*Proc. Ind. Sci. Congress* 1945, p. 141), the following compounds have been synthesised. Ethyl α -(2-carbethoxy-cyclo hexyl) adipate ($185^\circ\text{--}90^\circ/4\text{mm.}$) undergoes Dieckman's condensation, which on hydrolysis with 20% sulphuric acid for 16 hours gives the corresponding keto-acid which is esterified in the usual way and the keto-ester passes over at $156\text{--}58^\circ/6\text{ mm.}$ (semicarbazone, m.p. 191°). This on treatment with methyl-magnesium-iodide in ethereal solution gives the hydroxy-ester which is dehydrated in the crude stage with thionyl chloride and pyridine to give the unsaturated ester ($145^\circ\text{--}48^\circ/6\text{ mm.}$). This is hydrolysed with methyl alcoholic potash and the free acid is converted into acid chloride with thionyl chloride and pyridine and the distilled acid-chloride ($130^\circ/3\text{mm.}$) gives the methyl ester of the homo-acid on treatment with diazo-methane followed by Ag_2O and methyl alcohol. It boils at $145^\circ\text{--}50^\circ/6\text{ mm.}$

Ethyl *trans*-1-methylcyclopentane-1 : 2-dicarboxylate is partially hydrolysed with one molecule of caustic soda and the ester-acid is converted into acid-chloride. This on treatment with diazomethane, followed by hydrobromic acid gives the bromo-keto-ester ($130\text{--}36^\circ/6\text{ mm.}$). It condenses with sodio-maltonic ester in benzene solution to give the triester ($175\text{--}80^\circ/3\text{ mm.}$) in a poor yield. It is expected to hydrolyse it and to introduce a carboxyl group at the keto-group so that a fused system consisting of a cyclopentane and a cyclohexane ring in the *trans*-form, can be built up.

Biochemistry

137. Studies on the nutritive value of soya milk. Part 1. Comparison of the nutritive value of the proteins of soya milk and cow's milk.

H. R. S. DESIKACHAR, S. S. DE and V. SUBRAHMANYAN, Bangalore.

The protein value of soya milk compared to that of cow's milk has been determined both by the nitrogen balance method and by the growth method on rats. The digestibility coefficients and the biological values for the proteins as determined by the method of Chick have been found to be 89.7 and 82.8 for cow's milk, 90.9 and 79.2 for soya milk and 82.8 and 55.1 for raw soya beans. The average growth response of young rats per gram of protein consumed has been found to be about 2.0 g. and 1.8 g. in the case of cow's milk and soya milk respectively. The results of the experiments show that the protein of soya milk has a nutritive value which is about 90-95% as good as that of cow's milk protein. The experiment also shows the superiority of soya milk protein over raw soya-bean protein.

138. Digestibility of certain vegetable oils and fats determined by metabolic experiments on human beings.

K. P. BASU and H. P. NATH, Dacca.

The digestibility of the various vegetable oils and fats which are used for edible purposes in different provinces of India, e.g., mustard, coconut, sesame, groundnut,

cow-butter fat, buffalo-butter fat and Dalda Vanaspati was determined by metabolic experiments on adult human subjects. The method followed in these investigations was for the subjects to consume the fat in question, weighing 50 gms., with a basal ration of the composition : rice 600 gms., pulses 100 gms., vegetables 200 gms., fish (as far as possible fat-free e.g., icha or *palaemon carcinus*, hole or *Glossogobius gicris*) -60 gms.

Amount of fat intake and excretion was determined by analysis of food and faeces. Faecal fat excretion when only the basal diet was consumed and no oil or fat was taken was also determined and the percentage of digestibility was calculated on the oil supplement only.

The investigation showed that there are no very great differences in the digestibility of the fats studied. Practically in all cases the coefficient of digestibility exceeds 94% and there is no great difference in the digestibilities of the animal and vegetable oils and fats which are liquid at ordinary room temperature. Results with Vanaspati, however, indicates a comparatively lower value (89%). This is to be expected because hydrogenation raises the melting point of fatty acids which in turn lowers the absorption coefficients of fats and oils. There must, therefore, be an upper limit (preferably below 40°) for the melting point of hydrogenated fats and oils which the manufacturers should not be permitted to exceed.

139. On pharmacopoeial kaolin.

S. MUKHERJEE and K. K. DAS-GUPTA, Calcutta.

Kaolin is used in pharmacy either as a poultice or for oral administration. Studies of the chemical and physical properties of a number of commercial samples and also proprietary brands of medicinal kaolin show wide variations in adsorptive power for methylene blue, dispersibility and sedimentation volume. Successive treatments of commercial samples with HCl and NaOH followed by thorough washing with water reduces the proportions of Fe, O₂, CaO and MgO and slightly increase the alkali metal content. This treatment is accompanied with an increase in dispersibility and sedimentation volume. The adsorptive power is not always appreciably influenced by this treatment. The differences in adsorptive power are considered to be due to differences in the types of minerals present. The introduction of limit tests for adsorptive power and water-binding capacity (by sedimentation volume) in the different pharmacopoeas has been suggested.

140. Destruction of vitamin B₁ of some vegetables during cooking.

K. P. BASU and M. C. MALAKAR, Dacca.

Thiamin retention of thirty-five vegetables after cooking has been determined by the thiochrome method.

Some portion (20 to 100 per cent) of the thiamin content of all the vegetables investigated is destroyed by cooking. The average retention of vitamin B₁ of the vegetables investigated after cooking is about 60 per cent.

141. Yeast as food supplement in India.

K. P. BASU and P. K. DAS, Dacca.

Yeast contains about 50% good quality protein and has been used as a source of dietary protein in the Western countries. Investigations have been carried out on biological value of Food-Yeast (supplied by the Dept. of Food, Govt. of India) and its supplementary effect on poor rice diet.

(1) Biological value of yeast protein by growth method on young rats was carried out at 5% level of protein intake and the ratio : Gain in body-weight (gms.): Protein intake (gms.), was found on average to be 1.19, while the same ratios for the best variety of soyabean so far investigated here and for Bengal gram were found to be 0.97 and 1.07 respectively.

(2) Biological value of yeast protein by balance-sheet method on rats was found on average to be 71 and the corresponding digestibility to be 88 at 5% level of protein intake.

(3) Supplementary effect of yeast: Rats were fed on a poor rice diet and on poor-rice diet with 13% yeast supplement; the average increase in body weights of rats was respectively 3.44 gms. and 9.2 gms.

(4) Experiments on B. V. of yeast protein were conducted on two human subjects and on average was found to be 72.2, while the corresponding digestibility to be 90.5 at 5% level of protein intake. Human subjects were also kept on an ordinary diet of known nitrogen content to which yeast (5%) was added. The N-excretion was followed and better retention was observed.

142. On the loss of free and combined Vitamin B₁ of foodstuffs during cooking.

K. P. BASU and M. C. MALAKAR, Dacca.

The percentage destruction of free B₁ and of total B₁ in the case of nine different foodstuffs has been studied. It is found that 50 to 100 percent of the free vitamin B₁ is destroyed due to heat while the cocarboxylase portion remains unaffected.

143. A comparative study on the influence of alloxan and related compounds on blood sugar level by prolonged injection of these substances in rabbits.

M. C. NATH and D. D. MUKHERJEE, Dacca.

Alloxan and the related compounds with different CO : NH₂ ratios were studied to see if NH₂ group retards the glucose mobilizing tendency of CO group.

(a) With compounds, having the number of NH₂ groups equal to or in excess of the number of CO groups, there was gradual improvement of injection tolerance with the progressive course of continued daily injections.

(b) With compounds having the number of CO groups in excess to that of NH₂ groups, the injection tolerance was decreased progressively.

144. In search for new analectics.

U. P. BASU and S. P. DHAR, Calcutta.

For stimulating the respiratory and circulatory system various analectics are now-a-days being used. But the products, cardiazole, coramine, cardiaphone, cycliton, camphoric acid amide are not effective in all cases and all are not equally tolerated by the patients. If their chemical structure be scrutinised, then it would be noticed that they are either heterocyclic acid amides and/or some compounds containing a reduced nucleus. In view of the fact that various isoxazole derivatives are now being found to exert some analectic properties, various isoxazoles have been obtained by condensing hydroxylamine with cyclohexanone-2-oxalates. The resulting products on hydrolysis afforded two carboxylic acids—4: 5-benzo isoxazole 3-carboxylic and 3: 4-benzo isoxazole 5-carboxylic acids. These on treatment with thionyl chloride give the corresponding acid chlorides which can be directly converted to diethyl amide derivatives.

Similar diethyl amide derivative of 3-methyl-5-phenyl (or propyl)-isoxazole 4-carboxylic acids has been obtained (cf. B. P. 451913, 466555 and 514193). All these compounds are expected to be of some physiological interest.

145. Distribution of trace elements in biological material.

A. L. SUNDARA RAO, Delhi.

In continuation of the author's previous work (Proc. Ind. Acad. Sci., 1937, 6 B, 91, Science and Culture, 1938, 4, 362; J. Ind. Chem. Soc., 1940, 17, 351.) on the application of quantitative spectroscopy to the estimation of trace elements in soils and plant materials (cereals, pulses and leafy vegetables), further representative types of tubers (e.g. carrots, knoolkhol, onion, sweet potato) and fruits (e.g. Papaya, Tomato, Sapota, Plantain) have been analysed for their manganese content. The method used in the in-

tensity estimation is the "internal standard" method of Gerlach and Sweitzer as modified by Nitchie and Standen (*Ind. Eng. Chem. Anal. Ed.*, 1932, 4, 182). The 2801.1A° line of Mn is compared against 1802.7A° of Mg, chosen as the internal standard, and calibration curve has been obtained by plotting the intensity ratio $R \frac{I(M_n)}{I(M_s)}$ against

% Mn. The unknown percentages of manganose could be read off from the curve, from the known relative intensity of the lines in the test spectrum. Of the tubers examined 'knoolkhol' is very rich in Mn content, the average being 52 mgm. per kilogram of dry material and 'Onion' contains least, 5 mgm. The fruits are generally rich in manganese content.

146. A physico-chemical study of the cooking of Dhall (*Cajanus indicus*).

B. SANJIVA RAO, (MISS) H. RATNAMMA and (MRS.) P. LAKSHMIKANTAM, Bangalore.

A method of evaluating the cooking quality of dhal is described. Marked differences in the time required for adequate cooking of dhal are noticed in different samples. In the early stages of cooking there is considerable foaming. Effect of the foam on the cooking of the dhal and the prevention of foam, by addition of oil are discussed while addition of starch helps cooking, proteins in general have a marked adverse effect. The rigidity of the structure of dhal seems to be due to a protein-starch complex. Factors which promote a breaking up of the complex help the disintegration of dhal. The practical importance of these findings in the production of good-cooking dhal is indicated.

147. Studies on the nutritive value of soya milk. Part II. Comparison of the total B complex vitamins of soya milk and cow's milk.

H. S. R. DESIKACHAR, S. S. DE, and V. SUBRAHMANYAN, Bangalore.

A comparison of the total B complex vitamins of soya milk and cow's milk has been made by growth experiments on rats. After depleting the body store of the B complex vitamins in the rats by feeding them for two weeks on a basal diet which is nutritionally complete except for the B complex vitamins, the experimental period began. During this period the rats were supplemented with suboptimal amounts of the B complex vitamins which were solely supplied by the milks. The experiment lasted for six weeks. The gain in weight of the rats in response to the B complex vitamins supplied by the milk supplements indicates that soya milk is about 80% as potent as cow's milk with regard to its vitamin B complex content.

148. Studies on the nutritive value of soya milk. Part III. Supplementing value of soya milk to a poor South Indian diet.

H. S. R. DESIKACHAR, S. S. DE, and V. SUBRAHMANYAN, Bangalore.

A typical South Indian poor rice diet served as the basal diet. Three groups of young rats, six in each group, were selected. While the rats in the first group received the basal diet only rats in groups 2 and 3 were given supplements of soya milk at different levels. The growth response of the rats was studied over a period of seven weeks. The average weekly gain in weight of the rats has been found to be 2.8, 4.1 and 5.5 grams respectively for the three groups. The experiment therefore shows that an adequate amount of soya milk has a beneficial effect in supplementing a poor South Indian diet. This result is interesting in view of the fact that Dr. Aykroyd and Krishnan (*Ind. Jour. Med. Res.*, 25, 1938) have found that raw soya-bean has no beneficial effect as a supplement to a poor South Indian diet.

149. Nutritive value of insect-infested foodgrains and of grains deinfested by heat treatment.

C. N. BHIMA RAO AND V. SUBRAHMANYAN, Bangalore.

There is very little information available regarding the nutritive value of insect-infested foodgrains and the reclaimed material. The insects infesting the foodgrains

which attack the pericarp of the grain and bore through the germ of the grain and reduce a large part of the grain to 'flour' reduces the vitamin B₁ content both by their own consumption as well as by the mechanical damage caused by them.

Wheat, jowar, tur dhal and Bengal gram have been studied with respect to their normal vitamin B₁ content during insect infestation and after reclamation by flash heat treatment.

Although the insects form only a small part of the bulk of the stored grain, their consumption of the vitamins and the mechanical damage they cause are so great that in cases of moderately heavily infested foodgrains, nearly 50% reduction in vitamin B₁ can be noticed. Reclamation of insect infested foodgrains by flash heat treatment at 82 to 100° in three minutes shows no further reduction in vitamin B₁ content.

150. The fatty acid structure of buffalo ghee.

K. T. ACHAYA AND B. N. BANERJEE, Bangalore.

An analysis was made of the fatty acid structures (expressed below as molar percentages of acids) of three samples of buffalo ghee of high (38) low (20) and normal (30) R. M. value in excellent condition. The palmitic acid contents were high at about 28% and the stearic acid contents low at about 13%. The content of oleic acid followed roughly the Iodine value of the original ghee, and since these are usually low, the oleic acid figures were of a small order (17% corresponding to I. V/27.4).

The presence in buffalo ghee of the following was tentatively postulated: (i) unsaturated acids lower than oleic. (ii) an unsaturated acid higher than linoleic in substantial amounts. (iii) a saturated acid higher than stearic. A sample of rancid ghee analysed showed a high figure for lower saturated and lower unsaturated acids, probably resulting from the breakdown of oleic or linoleic acid. Acids approaching constancy were (i) palmitoleic at 3%. (ii) the sum myristic, palmitic and stearic at 53%. (iii) probably the linoleic to some extent.

151. The influence of cotton-seed feeding on the milk-fat of buffaloes.

K. T. ACHAYA and B. N. BANERJEE, Bangalore.

A study was made from month to month for a year of the analytical characteristics of buffalo ghee from several cotton-seed feeding areas—Probandar, Kosindra, Central Provinces (cotton tract), etc. The results showed the following features for such ghee: low R.M., P.V. and S.V., and high I.V. and B.R. (at 40°).

A fatty acid analysis made of two such ghees confirmed the lowered production of lower acids (R.M.+P.V.) and the increased production of the unsaturated oleic acid. A further feature was the remarkably high content of stearic acid coupled with a low palmitic acid content which was probably a mathematical consequence of the former. The source of the high stearic acid in the milk-fat was probably the oleic or linoleic acid constituents of cottonseed oil; it cannot be dietary stearic acid itself since the latter occurs only to the extent of about two percent in cotton-seed oil.

152. The analytical constants of ghee.

K. T. ACHAYA and B. N. BANERJEE, Bangalore.

In an attempt to study the limits of variation of, and the interrelationship (if any) between, the analytical constants of ghee, a hundred and sixty samples of the genuine product from all over India were examined for R.M., P.V., I.V., S.V., and B.R. (at 40°C). The analytical figures obtained indicated that a definite correlation between the constants existed, and that it was different for cow and buffalo ghee. Taking the R.M. value as standard, the cow ghees are associated with a higher P.V., higher I.V. and a far greater range of refractometer readings than those derived from the buffalo.

An empirical relationship existing between the constants was given by the formula

S.V

— which amounted for cow ghee to 3.48, and for buffalo ghee to 3.75.

R.M+P.V.+I.V

153. Transmethylation as a metabolic process in guinea-pigs.

SACHCHIDANANDA BANERJEE, Calcutta.

The metabolic reactions involved in transmethylation have been studied in rats, rabbits and man and it has been observed that they behave similarly. The metabolic

requirements of guinea-pigs, however, differ greatly from those of rats and rabbits. For example the guinea-pigs, unlike rats and rabbits, require vitamin C and other dietary factors. It was therefore of interest to investigate if the process of transmethylation occurs also in guinea pigs. Guinea-pigs were fed a synthetic diet consisting of sucrose, dextrin, cellulose, casein, salt mixture and all the known vitamins for one week and then they were given deuteromethionine (75 mg. per 100 g. body weight) for three days. The animals were sacrificed on the eleventh day of the experiment. Creatine and choline were isolated from the body tissues as creatinine potassium picrate and choline chloroplatinate respectively. Deuterium in the samples was determined by the isotopic technique. Deuterium from the diet was found to be transferred to the creatine and choline of the body tissues indicating that transmethylation is a biological process in guinea-pigs.

154. Effect of fat on galactose utilisation.

SACHCHIDANANDA BANERJEE, Calcutta.

It has been observed by Elvenjem and his co-workers that skimmed milk-fed rats excrete galactose in their urine. When these rats are given butter fat or corn oil they cease to excrete galactose. These results indicate that fat plays some role in the utilisation of galactose. It is of interest to study the mechanism by which fat helps in the metabolism of galactose. The glycogen content of the liver of whole milk-fed rats and rats receiving isocaloric amount of skimmed milk have been determined. It has been found that the glycogen content of the liver of skimmed milk-fed rats is greatly lowered than the rats receiving whole milk diet. On incubation of liver slices with galactose it has been observed that the liver slices from the rats receiving skimmed milk cannot convert galactose into glycogen. These results indicate that fat helps in the conversion of galactose into glycogen in the liver and in its absence the liver cannot convert galactose into glycogen in the liver, galactose is excreted in the urine.

155. Purification of leaf phosphatase.

R. DAS and K. V. GIRI, Bangalore.

Various methods of purification of leaf phosphatase have been studied. The method finally adopted consists of (a) fractional precipitation from its aqueous solution with alcohol (b) adsorption on Al_2O_3 (C) followed by elution with 10% sodium tartrate and (c) dialysis or ultra-filtration. The enzyme has been concentrated 150-fold by this method. The chemical nature and other general properties of the purified enzyme have been studied.

156. The chemical composition of papaya pectin and physico-chemical studies on Papaya pectin-acid-sugar jelly.

C. R. KRISHNAMURTI and K. V. GIRI, Bangalore.

With a view to elucidate the composition of papaya pectin, pure specimens of the product have been prepared using different methods of purification.

Acid hydrolysis of the pectin has been carried out and the products of degradation studied completely.

Attempts have been made to prepare *d*-galacturonic acid from papaya pectin.

The various physico-chemical factors affecting papaya pectin jelly formation are under investigation.

157. Manganese in the formation of vitamin C and carotene in plants (*Amaranthus Gangeticus*).

Y. B. RANGNEKAR, Bangalore.

Investigations were carried out on *Amaranthus* plants (known to be very rich in vitamin C and carotene) grown in pot cultures with local soil low in available manganese. From the results obtained for the control and four treatments of manganese (as $MnSO_4 \cdot 4H_2O$), the amounts applied being 0.05, 0.1, 0.2 and 0.3 gms., respectively per pot (6 lbs.), it seems that the formation of vitamin C is influenced to various degrees by

the added manganese, higher concentrations being apparently harmful for the same. This action of manganese seemed to run parallel with that in promoting the growth of the plant and hence was indicative of its overall influence on the metabolic processes of the plant.

The role played by manganese is suggested as that of a coenzyme or activator of the enzymatic systems responsible for the biosynthesis of vitamin C in plants from hexoses such as gulose or mannose. In this connection, mention may also be made of the recent work which indicates that dehydroascorbic acid functions as the first precursor of vitamin C in plants and that a reductase system responsible for the conversion has been found to exist in plants.

The carotene formation in the plants was found to be practically uninfluenced by the manganese treatment

158. Jack fruit—its composition and utilization.

H. D. KARAMOHANDANI, Bangalore.

Pectic acid of the pulp corresponds to 8.4 mgm. of potassium hydroxide per gram of the pulp. Soluble matter of the pulp consists of sugars to the extent of about 90%, both reducing and sucrose. Pectin content of the seed and non-edible portion as estimated by ammonium oxalate extraction is 6.3 and 5.6 to 6.0 per cent. respectively.

The seed is comparatively richer in proteolytic enzyme content. The pulp contains diastase enzyme. The pulp is a pretty good source of vitamin C in view of the large consumption of the fruit. Seeds are fairly rich in mineral content. They make good curry for vegetarians. The seed flour can be used for chappati and bread making.

Sugars of the pulp contain material capable of resinification.

The pulp makes good preserves.

159. Jack fruit seed flour as an emulsifying agent in preparation of salad dressings.

H. D. KARAMOHANDANI, Bangalore.

Comparisons of dressings made from cooked and uncooked jack with egg-yolk and egg-white dressings have been made. The comparisons include microscopic examination of the oil droplets as well as quantitative measurements of the relative viscosity.

From the observations made, it seems that the quantitative evaluation of salad dressings should include not only a measure of stiffness or viscosity, but also a comparison of their stabilities dependent mainly upon the size of the dispersed droplets. The results bear out that the jack fruit seed flour can be successfully used as an emulsifying agent in the preparation of salad dressings. The emulsions obtained are less finely dispersed than those produced from an equal proportion of yolk solids but are practically identical in droplet size to egg white emulsions made over the same formula.

The relative viscosity of the jack fruit seed flour dressings is much greater than those from either yolk or white, hence making possible the preparation of inexpensive salad dressings using jack fruit seed flour as the sole emulsifying agent.

160. The influence of linoleic acid on the utilisation of carotene from oils.

S. DATTATREYA RAO, Bangalore.

Variations in the growth-response of vitamin A-deficient rats to carotene dissolved in different oils has not been satisfactorily explained. Sherman's (1941) theory that the differences were partly due to the linoleic acid content of the oils, has been examined and found to be incorrect. Carotene fed in groundnut oil and in cottonseed oil which contain widely varying amounts of linoleic acid produced almost the same growth in vitamin-A deficient rats. Coconut oil containing far less linoleic acid produced much poorer growth. The addition of pure ethyl linoleate to coconut oil and to groundnut oil to bring up the total daily intake to the same level as in cottonseed oil, however, did not produce any difference in the rate of growth. The differences in faecal excretion of carotene, determined during the course of the assay, were too small to explain the differences in growth-response.

161. The influence of vitamin E on the utilisation of carotene from oils.

S. DATTATREYA Rao, Bangalore.

Examination of the vitamin E contents of a number of oils which were used as solvents for administering carotene to vitamin A—deficient rats indicated that the order of growth-response to carotene was the same as the order of vitamin E content. The effect of equalising the level of tocopherol in the supplements was next studied. The same dosage of carotene dissolved in groundnut oil, olive oil and coconut oil produced varying response in the order indicated; when the total intake of vitamin E was equalised by adding the calculated amount of L-tocopherol to olive oil and to coconut oil, the growth-rates increased and the differences became negligible. The results show that the growth responses to carotene fed in different oils depend mainly on their vitamin E contents.

162. On the biosynthesis of vitamin C in caprica papaya.

Y. B. RANGNEKAR, Bangalore.

Investigations carried out on Papaya fruit during the period of its growth, indicated that dehydroascorbic acid possibly acts as the first precursor of vitamin C in the fruit during its growth. The dehydroascorbic acid content of the flesh of the fruit which was of the order of 20 to 40% of the total vitamin C in its very young stage, fell down to as much as 2.5 to 6% in the ripe stages of the fruit while that of the skin fell down from 6-12% to practically nil. It was also found that the green skin was invariably richer in ascorbic acid than the flesh during all the stages of growth excepting the ripe ones when it was somewhat lower. This observation indicated the greater formation of vitamin C in the green parts i.e., those containing chlorophyll and hence its association with the process of photosynthesis. On the average it was seen that the vitamin C content in the skin of the fruit decreased with the development and the consequent increase in the weight of the fruit.

163. On the presence of ascorbic acid-oxidising enzymes in caprica papaya.

Y. B. RANGNEKAR, Bangalore.

Oxidising enzymes capable of oxidising ascorbic acid to its oxidised form were found to be present in papaya fruit. Although detailed investigations were not carried out, it appears from the initial experiments that the enzymic system is possibly ascorbic oxidase in nature. The activity of the oxidising enzymes was found to be maximum at the very raw stage of the fruit and was decreasingly less at the semi-ripe and the ripe stages. The much higher concentration of dehydroascorbic acid in the very young stage of the fruit as compared to the ripier stages, may partly be due to the above, although ascorbic acid protecting systems as are reported to exist in plants, may also be present in the fruit.

The pH of the fruit (flesh) decreased with its growth, an observation rather significant in view of the greater stability known of ascorbic acid at low pH.

164. An enzymic method for the detection and estimation of fluorides in water.

R. DAS and K. V. GIRI, Bangalore.

The striking inhibiting effect of fluorides on leaf phosphatases is made the basis of a simple method for the detection and estimation of small quantities of fluorides in water. The percentage inhibition is found to be strictly proportional to the concentration of fluorine in water. An extrapolation method is described which makes correction for the slight effect of other interfering substances present in water.

165. The sparing action of α -tocopherol on carotene.S. DATTATREYA RAO, V. MAHADEVAN and Y. B. RANGANEKAR,
Bangalore.

The existence of vitamin A—E synergy has been confirmed at four levels of tocopherol. A supplement of carotene (0.8 μ g. daily in coconut oil) which was by itself insufficient to maintain life in vitamin A-deficient rats, became adequate and supported growth when tocopherol was simultaneously given. Increasing doses of tocopherol produced increasing growth-rate, the optimum being about 0.5 mg. tocopherol per rat per day.

166. Pectin content of some of the common fruits and vegetables.

C. R. KRISHNAMURTI and K. V. GIRI, Bangalore.

Pectin content of some of the common fruits and vegetables has been determined by the following four methods. (1) Alcohol precipitation, (2) Calcium pectate, (3) Pectic acid precipitation and (4) Titration method. The last one has been standardised so as to be used as a routine method in plant analysis. Among the fruits and vegetables analysed, the papaya and jackfruit are found to be as rich in pectin as apple.

Conditions for the large-scale preparation of pectins from indigenous sources have been standardised.

Analytical data for a number of pectins prepared by the acid method of extraction and the ammonium oxalate method of extraction are given.

Applied Chemistry

167. Ammonium alum as catalyst for production of ethers.

S. K. K. JATKAR and T. SUBRAHMANYAM, Bangalore.

The authors have studied the formation of ethyl and butyl ethers and methyl-*iso*-amyl ethers over alum as a catalyst. The limit of etherification in each case has been determined.

168. Catalytic dehydration of castor-oil.

S. K. K. JATKAR and N. K. NARAYANA, Bangalore.

A good dehydrated castor oil is obtained by employing in small batches $1\frac{1}{2}$ to 2% of $\text{Na}_2\text{SO}_4 + 0.6 \text{ H}_2\text{SO}_4$. By using kerosene vapour instead of carbon dioxide, a dehydrated castor oil with a low viscosity and pale colour is produced. Continuous addition of small quantity of the catalyst was found to yield the best results.

A fresh catalyst must be used for each batch of dehydration since the catalyst loses its acidity after one use partly by sulphonation of the oil and partly reduction to sulphur dioxide.

The progress of dehydration can be followed by the amount of water evolved. The dehydration of the oil was found to follow the law of unimolecular reaction.

169. Estur gum.

S. K. K. JATKAR and N. K. NARAYANA, Bangalore.

Linseed and cashew shell oils do not show any catalytic activity for esterification of rosin. China wood oil has a definite catalytic action. Dehydrated castor oil is found to be a far superior catalyst than wood oil and is easily cooked up in further quantities of linseed and dehydrated castor oil. The reaction can be easily followed by the amount of water collected.

The velocity constants of the esterification of rosin have been calculated assuming uni-molecular law.

170. Technology of shark liver oil.

C. C. JOHN, P. V. NAIR and T. A. RAMAKRISHNAN, Trivandrum.

An improved technique of extraction, refining and storage of shark liver oils based on scientific experience gained in the laboratory and in the factory has been evolved by the authors. Special attention has been bestowed on sorting of the liver mass which is used in the extraction, and a method of refining the oil obtained from "autolysed" livers is suggested. Full details for the pilot plant extraction of shark liver oil for refining and destearinisation and for storage and final standardisation of the oil without adulteration with vegetable oils are set forth in the paper. The use of an antioxidant substance "antoxyl" for stabilising the oil against deterioration in storage is recommended and the conditions for bulk and retail storage are specified.

171. Autoxidation of shark liver oil, Part II. Viscosity of rancid and fresh oils.

P. V. NAIR, S. RAMACHANDRA VARIER and T. A. RAMAKRISHNAN, Trivandrum.

The kinematic viscosities (expressed as centistokes) of samples of fresh and rancid shark liver oils and mixtures of both have been determined. The rancid sample returned a greater viscosity index than either the fresh oil or an admixture with fresh oil. The rancid oil for the use of the experiment was made by exposing fresh oil for one year when its iodine value was reduced from 140 to 89. The iodine value of the fresh oil used in the experiment was 90, thus ensuring that the iodine values of the fresh and rancid samples were approximately the same. Viscosity graphs plotted from the data obtained from these experiments afford evidence to show that the viscosity of a mixture of equal volumes of fresh and rancid samples is very nearly the mathematical mean of the values for the unadulterated samples. The difference in viscosities of fresh and rancid oils decreases with increase in temperature and the graphs seem to converge at high temperatures. This convergence of the curves for viscosity of rancid and fresh oils at high temperatures may be construed as tending towards the establishment of common characteristics for both oils at such temperatures and as affording theoretical support to the idea that preheated rancid oils could be admixed with fresh vitamin rich oils in standardised conditions of manufacture. It has also been observed that after a maximum rise in viscosity is reached the oil tends to become mobile during the development of autoxidative changes before it ultimately resinifies.

172. Autoxidation of shark liver oils. Part III. Species specificity of induction period of shark liver oils.

P. V. NAIR and T. A. RAMAKRISHNAN, Trivandrum.

The comparative response of oils obtained from the two better known species of sharks indigenous to Travancore waters, *Stegostoma tigrinum* (tiger shark) and *Pristis cuspidatus* (saw fish) to a common antioxidant has been studied. The difference in the induction period of the two species was notable and furnishes an indication that the oils are endowed with different kinds of trace substances in their systems. Saw fish liver oil has been observed to possess a more marked induction period and has superior keeping qualities. Curves of peroxide development after the administration of the inhibitor reveal that there is a complete disappearance of peroxides in tiger shark liver oil on the third day of the experiment. This is presumed to be due to the fact that the decomposition products created by the interaction of the peroxides with the trace substances (tocopherols) present in the substrate contribute their own antioxidant properties and acts synergistically with the foreign inhibitor. The mechanism of this action would appear to be the formation of chroman-5:6-quinones by the interaction of tocopherols with the peroxides and the chroman-5:6-quinones act in turn as antioxidants and prolong the induction period till the quinoid compounds are completely disappeared (c f., Boem and Williams, *Pharmaceutic. J.*, 1943, 151, 163).

The saw fish liver oil does not appear to respond to the treatment of the inhibitor so well as the tiger shark liver oils and pronounced prolongation of the induction period discernible with the latter does not appear to take place. This by inverse argument would mean that saw fish oils are very much poorer in vitamin E than tiger shark oils. Admixture of saw fish oil with tiger shark oil, however, induces an additive response to the action of the antioxidant which for all practical purposes appears to be satisfactory. This fact points to the commercial possibility of blending tiger shark oil rich in vitamin E with saw fish oil rich in vitamin A so as to get a fair degree of response to the foreign inhibitor and to ensure uniform distribution of vitamins A and E.

173. Autoxidation of shark liver oils. Part. IV. Organoleptic rancid point.

P. V. NAIR and T. A. RAMAKRISHNAN, Trivandrum.

By the judicious exercise of the senses of smell and taste it is possible within reasonable limits to adjudge the quality and age of liver oils and this test popularly known as 'organoleptic assay of rancidity' according to Davidsohn (*Chem. Ztg.*, 1930, 54, 606, appears to be still the most sensitive as well as the most dependable test for the assay of rancidity in fixed oils. The present work was designed to see how far the organoleptic rancidity of an oil agreed to the data indicated by peroxide values. We have found that development of organoleptic rancidity coincided within a fairly narrow range (60

milli-equivalents of peroxides per kg. of oil) with the conclusion of the induction period under the conditions of the experiment and also that under closed storage conditions development of organoleptic rancidity may take place at as low a peroxide value as 8.

174. Antioxidants for shark liver oil. Part. V. Influence of certain inorganic substances on the stability of the oil.

P. V. NAIR and T. A. RAMAKRISHNAN, Trivandrum.

The course of autoxidation of shark liver oil as influenced by the presence of certain inorganic substances like sodium chloride, anhydrous magnesium sulphate, anhydrous sodium sulphate, aluminium powder, nitrous oxide, potassium cyanide and water has been studied and the results set forth in tabular form. As some of these substances find application at some stage or other in the technology of shark liver oil it has been a matter of intrinsic interest to find out how these substances would affect the stability of the oil. The use of sodium chloride, magnesium sulphate, sodium sulphate and aluminium does not adversely affect the stability of the oil and is, therefore, quite unexceptionable. Aluminium has only the very slightest tendency to promote autoxidation and next to zinc it is the very best metal for use as containers for shark liver oil. The course of autoxidation is very little affected by the presence of water upto a limit of 10% of the weight of the oil.

175. Antioxidants for shark liver oil. Part. VI. Influence of certain hormones, starches, and vegetable oils on the stability of the oil.

P. V. NAIR and T. A. RAMAKRISHNAN, Trivandrum.

The supposed specific action of hormones on the stability of biological systems was anticipated to operate in an analogous manner on the development of autoxidative changes in shark liver oil. Under the conditions studied in the laboratory none of them with the exception of posterior pituitary extract gave any promise of antioxidant activity. The stabilising influence of a few starches obtained from plantain, tapioca and ginger as also of vegetable oils like groundnut, sesame and coconut has been investigated. Special significance was attached to the study of groundnut oil as a stabilising agent since it is popularly believed to have a beneficial effect on the stability of shark liver oil. Our experiments, however, reveal that although there is a slight prolongation of the induction period in shark liver oil-groundnut oil (1:1) systems the phenomenon is largely due to the fact that groundnut oil by itself is slow to undergo oxidation and that the addition of smaller proportions of groundnut oil to shark liver oil does not materially alter the course of autoxidation of the mixture.

176. Antioxidants for shark liver oil. Part. VII. Phenols and certain condensation products as stabilising agents for shark liver oil.

P. V. NAIR and T. A. RAMAKRISHNAN, Trivandrum.

The comparative merits of certain phenolic substances and condensation products as stabilising agents for shark liver oil have been investigated. Hydroquinone among the phenols and 2:6-dichlorophenol-indophenol (indicator for ascorbic acid) were found to have pronounced antioxidant properties. *o*-*p*-nitrobenzyl-6-nitrovanillinic acid produced a vehement drop in the development of peroxides as soon as it was mixed with shark liver oil but this drop was maintained only for a few days. It is worthy of note, however, that hardly any antioxidant studied in the course of this work had produced so vehement a drop in the initial peroxide content.

177. Studies on Travancore marine oils. Part. II. Whale oil, turtle oil and butter fish fat.

P. V. NAIR, M. SRIDHARAN PILLAI and T. A. RAMAKRISHNAN,
Trivandrum.

The physical and chemical characteristics of samples of whale oil (*Megaptera on-dusa*), turtle oil (*Dermochelys coriacea*) and butter fish fat (*Lacterius loctevius*) collected in Travancore have been ascertained and are set forth in tabular form.

178. A note on the tinctorial properties of the extract of coconut "Buttons".

P. V. NAIR and T. V. PUNNOOSE, Trivandrum.

A concentrated aqueous extract of the colouring matter of coconut "buttons" (the tender undeveloped fruits of *Cocos nucifera*, L.) has been found to yield tones varying from silver grey to dull black on iron-mordanted cotton hanks, and a fair degree of fastness is revealed by the dyed fabric. The residual cellulosic material after removal of colouring matter can be processed for the manufacture of good quality hand-made paper. This two-purpose process provides a means for the economic utilization of a waste material which is obtained in very large quantities on the Malabar coast.

179. Indigenous rubber yielding plants of Travancore, Part. II. *Taberna montana heyneana*.

M. SRIDHARAN PILLAI and S. K. MADHAVAN PILLAI, Trivandrum.

Taberna montana Heyneana (N. O. Apocynaceae) is one of the laticiferous trees of Travancore. The latex can be collected either by tapping the tree, in which case the yield was low, or by bruising the fruits and pressing out the latex (yield 9 to 10%). The following characteristics of the latex were noted. Acid value, 2.4; coagulated matter, 28.17%; steam volatiles, nil; specific gravity, 1.036; total solids, 31.86%; water soluble, 3.69% and ash value, 1.42 per cent. The dry rubber content is roughly 5.2 per cent of the weight of the latex.

180. Manufacture of strontium carbonate from Indian celestite ore.

MATA PRASAD and G. V. DANGE, Bombay.

The optimum conditions for the manufacture of strontium carbonate from Indian celestite have been exhaustively worked out. The celestite under investigation occurs in Punjab and is very rich in strontium sulphate content (97.8%). The powdered ore was first digested with sulphuric acid in order to remove iron, calcium and magnesium which are present in small quantities as impurities. The method adopted in the conversion of celestite is based on the metathetical reaction between strontium sulphate and a solution of alkali carbonate. The reaction has been investigated in aqueous solution and the effects of (i) time, (ii) excess of sodium carbonate, (iii) concentration, (iv) temperature, (v) size of the ore particles, (vi) rate of shaking, on the conversion of strontium sulphate to strontium carbonate have been studied. Optimum conditions for the maximum conversion (99.5%) have been determined. A pilot plant is being fabricated for this purpose.

181. Potassium salts from plant, wood and charcoal ashes.

S. KRISHNA, MATA PRASAD and G. V. DANGE, Bombay.

Various plant, wood and charcoal ashes have been investigated with a view to exploring the natural sources of potash-yielding plants of the Indian forests and thus finding economic uses of these hitherto considered waste-products. Some of the ashes of plant species like *Artemisia vulgaris*, *Lantana Camara*, *Ageratum conyzoides*, *Glycosmis pentaphylla* are found to contain appreciable quantities of soluble potash which varies from 25% to 40% on ash basis. Those plants have a high ash content and as they are available in large quantities, they can be considered as a good source of potassic salts. Some other plant ashes from species like *Achyranthus aspera*, and *Amaranthus spinosus* also have a very high potash content but their supply is doubtful. The ashes of leaves and twigs of common woods like *Cassia tora*, *Chenopodium album*, and *Colebrook oppositifolia* contain 25%, 27% and 40% of soluble potash respectively, and hence can be considered as good sources of potash. Among the leaves of the trees whose ash can be exploited economically for extraction of potash, only *Mallotus philippinensis* has been found to be a good source.

The ash content of charcoal and woods have been found to be very low, varying between 0.07% and 0.5% as against the plants in which it varies between 0.5% and 20 per cent. Some of the charcoal ashes of species like *Kydia calycina*, *Mangifera indica* *Prosopis speigera* have been found to contain soluble potash between 28% and 40 per cent. These can serve as good source of potash where industrial concerns use charcoal for their fuel purposes. The choice of all the various ashes analysed for their commercial exploitation has been considered taking into account factors like (i) potash content

of the ashes, (ii) ash content of the plants and woods, (iii) the availability of the plants, (iv) cost of collection. Pilot-plant experiments for the extraction and separation of potash salts from such ashes are under progress.

182. Utilisation of groundnut meal. Part III.

U. P. BASU and S. SEN-GUPTA, Baranagar (Calcutta).

In almost every country some sections of the community suffer in health from lack of proteins of good nutritional value. Milk, meat, fish and eggs are not always easily available; but there are other sources whence we may secure our protein food. The quality of a protein is dependent on the nature of amino acids contents; as such groundnut protein containing many essential amino acids may offer us a 'quality' protein provided we may get its protein free from the fibre, and excess of oily matter.

With this end in view ground nut meal has been processed for the isolation of its protein. Direct alkali extraction and subsequent acidification gives a proteinous body but much of its vitamin and salt is lost during the isolation of the protein food. The meal has also been subjected to digestion by *Aspergillus Oryzoe*. A solvent-extracted meal as well as expressed meal was autoclaved for different periods under different pressures and the various charges were inoculated with a culture of *Asp. Oryzoe* and left to mature for months. It was noticed that about 80% of protein was digested in most cases within a period of two months. The various lots of the digest, thus obtained, had been adjuvated with other suitable materials to make the same palatable. It may be noted that the digest under the above circumstances would contain most of the vitamins and minerals of the original nut.

183. Resins from benzyl chloride and phenol.

P. S. VARMA and K. S. RADHAKRISHNAN, Benares.

It has been reported that benzyl chloride reacts with phenol in presence of catalysts to yield a thermoplastic resin, which can effectively be used as a varnish material, insulating material or sealing wax. (*Jour. Soc. Chem. Ind.*, 1921, 40 210; 1925, 44, 216). The reaction between benzyl chloride and phenol has been studied systematically, using (i) various catalysts like FeCl_3 , AlCl_3 etc. (ii) changing the proportion of the reactants and (iii) the period of heating. The properties of the plastics so prepared, like colour, density, plasticity, coating power and the solubility in organic solvents as well as in drying oils have been studied. Similar resinous products are obtained if benzal chloride is substituted for benzyl chloride and the resins so obtained seem to be more promising and in certain respects of better quality.

184. Studies in properties of glass.

PRODOSH CHANDRA RAY CHOUDHURY, Calcutta.

Inhomogeneity of glass is one of the most difficult problems of glass technology. To this cause may be ascribed a great deal of the change in properties of glass. The tank is probably the worst offender in producing this condition. Not enough attention is being given to this matter.

The composition of glass as shown by analysis rarely agrees accurately with the composition calculated from the batch used. The important factors which cause this differences are:—

- (a) The presence of impurities in the raw materials
- (b) Loss of constituents from the glass by volatilization
- (c) Solution of refractories in the glass
- (d) Inhomogeneity of the finished product.

Special investigations should be made to find out the cause of inhomogeneity of the finished product by both chemical and physical tests.

185. Inhomogeneity of glass.

PRODOSH CHANDRA RAY CHOUDHURY, Calcutta.

Experiments made to investigate the nature of change taking place in the composition of glass show that

- (a) Inhomogeneity depends upon the difference of composition of the same glass.
- (b) the composition of glass varies during the period of a working day
- (c) the percentage of B_2O_3 and alkali is mostly responsible for the difference in durability of different types of glass

- (d) in some particular cases the durability also depends upon the size and annealing of the samples.
 (e) the pH of the glass varies with the inhomogeneity of the sample.

186. Action of nitrogen peroxide and oxygen on cotton cellulose.

G. M. NABAR, C. V. PADMANABHAN and K. VENKATARAMAN,
 Bombay.

Studying the oxidation of cotton cellulose by nitrogen peroxide, Kenyon and others (*J. Amer. Chem. Soc.*, 1942, 64, 121, 127) found that highly acidic oxycelluloses were produced, but the fibrous structure was maintained; oxycelluloses with carboxyl content of over 13.5% dissolved readily in dilute alkali. While the present investigation was instituted with the object of preparing such oxycelluloses in quantity and studying their utility in sizing, finishing and printing, it has been observed that the combined action of nitrogen peroxide and oxygen exhibits many features of interest from the point of view of the mechanism of the oxidation of the cellulose macro-molecule. The rate of oxidation increases with an increase in the partial pressure of oxygen, and the carboxyl content increases steadily with progressive oxidation. On the other hand, the copper number attains a maximum value of 85 at which it remains constant. Treatment of the nitrogen peroxide oxycelluloses with boiling 1% alkali reduces the copper number in all cases to about 25. Products with a carboxyl content of over 5.5%, a much lower figure than that quoted by Kenyon *et al.*, are completely soluble in dilute alkali. The highly oxidised oxycelluloses prepared by the present method contain about 2.5% nitrogen, and their constitution is being submitted to further examination.

187. Splitting of tallow fat by Twitchell's process for manufacture of stearic acid B.P.

RAMAN PATEL and C. S. PATEL, Baroda.

During the last three years due to import position being very difficult there was a steady unfulfilled demand of stearic acid for pharmaceutical and industrial uses. Indian muttan tallow is an important source for stearic acid. The investigations under report were carried out to determine the conditions of purification and establishing complete data regarding the splitting of muttan tallow available from local slaughter houses, by Twitchell Reagent (T.R.) to produce Stearic Acid of B.P. purity.

The investigations comprise of the effect, on the splitting of tallow of (1) Purity of fat (2) Amount of T.R. (3) Temperature of reaction (4) Amount of Sulphuric Acid and Oxalic Acid (5) T.R. prepared by different sulphonating agents with varying conditions of temperatures and time. (6) T.R. preserved for different periods (7) T.R. prepared by using Naphthalene, Benzene and Phenol.

A pilot plant capable of processing one ton of tallow to get about nine Cwt. of stearic acid is put under operation using the optimum conditions arrived at from the above data.

188. On the extraction of vitamin from shark liver oil.

U. P. BASU and S. SEN-GUPTA, Baranagar (Calcutta).

For obtaining a vitaminic concentrate of better taste and odour from shark-liver oil experiments have been conducted with a sample of oil kindly supplied by Dr. S. B. Setna of Bombay. (Shilling the oil in presence of ground nut and sesame oil in order to transfer the vitamin present to the vegetable oil portion met with no success in our hands. More than 25 per cent of the vitamin can be extracted out by alcohol. Subsequent removal of alcohol from the extract offers a concentrate of high potency and agreeable odour. Better results are expected from experiments that are being carried out with saponified oils. The soap solution may be easily extracted with suitable commercial immiscible solvents in a specially constructed vessel. The resulting extracts contain most of the vitamin present in the original oil. Work is in progress.

189. Study in alcohol-soluble nitrocellulose.

D. R. DHINGRA and SUBRATTA DUTTA, Delhi.

For the preparation of alcohol-soluble nitro-celluloses possessing good film properties, conditions of acids-concentration, temperature, time, etc. have been studied. For 3 gms. cotton wool and acid mixture of 50 c.c. HNO_3 (d 1.4) + 100 c.c. H_2SO_4 (d 1.8) and

25 c.c. water, temperature of 40°C and time range of 30 minutes produce somewhat better product as regards yield, solubility in alcohol and film strength, than that with 30, c.c. water, 35°C temperature and 45-60 minutes' time, but the differences are slight.

Methyl alcohol is a better solvent than ethyl alcohol for nitro-cellulose. The product having 8.5-11.0% nitrogen, are fairly soluble in methyl alcohol but for ethyl alcohol, the best range is 9.5-10.5% of nitrogen which also results in a better film than the former, considering transparency and tensile strength. Product soluble in ethyl alcohol produces a better film and the solution plasticises better with castor oil and dibutyl phthalate than in methyl alcohol.

190. β -Naphthol as a textile antiseptic.

N. F. DESAI, A. SREENIVASAN and K. VENKATARAMAN, Bombay.

While there are few references in literature to the value of β -naphthol as an antiseptic in sizing and finishing, extensive experiments have shown that β -naphthol deserves serious consideration as a textile antiseptic. It has been shown by Gandhi and Venkataraman (*J. I. C. S., Indl. Ed., 1942, 5, 79*) that β -naphthol is comparable with so outstanding an antiseptic as salicylanilide, tested both by *in vitro* and *in vivo* methods. Further experiments using a heavy size, particularly favourable to mildew, on cotton fabrics, as well as large scale trials in a mill, have fully confirmed the high efficiency of β -naphthol in preventing mildew growth. Examining a series of antiseptics with regard to their behaviour towards cultures of individual organisms, such as *Aspergillus niger* van Tieghem, *Chaetomium globosum*, *Penicillium notatum* von Fleming and *Cladosporium haerbarum*, β -naphthol has been found consistently to be greatly superior to salicylic acid and about half as effective as salicylanilide. β -Naphthol has the advantage over other phenolic compounds that it has no objectionable odour and it leaves no stains in subsequent processing.

Temperature appears to play an important part in the relative efficiencies of antiseptic; and β -naphthol, salicylanilide and other antiseptics are being submitted to a careful examination from this point of view.

In evaluating antiseptics by accelerated tests, it is convenient to employ cloth sized with maize starch and Czapek's nutrient medium containing glucose, and to subject it to an aqueous suspension of mixed cultures in Petri dishes.

191. Electrolytic preparation of calcium gluconate.

C. S. PATEL, M. D. AVASARE and B. V. PARIKH, Baroda.

Calcium gluconate occupies an important place as a therapeutic agent in the treatment of calcium deficiency and it was thought worth while to study the oxidation processes by the electrolytic methods to produce it from easily available raw material starch. The role of various electro-chemical factors, such as concentration of calcium bromide as the electrolyte, the temperature, the inter electrode spacings, the current density at the anode etc. has been investigated. The effects of addition of chlorides and halides along with calcium bromide and individually upon the yield of calcium gluconate have been studied. Salts other than halides have also been tried to improve current efficiency. In some twenty experiments, the rate of oxidation has also been studied specially under different concentrations of calcium bromide and under different anodic current densities. Optimum conditions have been settled and a process for the manufacture of calcium gluconate has been evolved.

192. Investigation on Indian rosin and its esterification for ester gum manufacture. Part I.

C. S. PATEL, M. D. AVASARE and R. D. PATEL, Baroda.

Forest resources of India afford various products of industrial importance. Rosin and turpentine are some of the most important industrial raw materials obtained from Pine Oleoresin commonly known as 'chir'. The present work has been carried out with a view to investigate thoroughly Indian Rosin. Its physical and chemical properties have been studied in all details and the products of its esterification with glycerol in presence of various catalysts have been investigated for their suitability as raw materials useful in varnish and printing ink industries.

This part mainly deals with the physical and chemical properties of Indian W. W. rosin which is found to have properties resembling to a greater extent the American rosin. A comparative study of properties of Indian and American rosin has been attempted.

193. Investigation on Indian rosin and its esterification for ester gum manufacture. Part II.

C. S. PATEL, M. D. AVASARE, and R. D. PATEL, Baroda.

In this part a laboratory method has been devised for preparing ester gum under controlled conditions so that it can be compared with respect to colour, softening temperature and the rate of esterification. The effect of catalysis on the rate of esterification is studied in details using different types of catalysis *viz* :

- | | |
|--------------------------------|---------------------|
| 1. Metallic | 2. Metallic oxides, |
| 3. Organic acids, | 4. Inorganic salts, |
| 5. Drying and non-drying oils. | 5. Driers. |

Also ester gums are prepared from modified Indian rosin and rosin acid. Rate of esterification of abietic acid has also been studied. An apparatus has been designed for esterification of rosin in light of our above findings so as to manufacture ester gum on a semi-commercial scale.

194. A new method for the rapid determination of the extent of degumming of silk.

R. S. SUBRAMANYA and B. SANJIVA RAO, Bangalore.

The extent of degumming of silk is usually determined by estimating the loss in weight of silk when treated with detergents under suitable conditions. This procedure is time-consuming and is not sufficiently accurate. A rapid method of determination, developed in this laboratory, consists in autoclaving one gram of silk with 10 c.c. of water at 10 lbs. pressure. The protein in an aliquot of the extract is estimated by the micro-Kjeldahl technique. This value is found to be a correct measure of the extent of degumming.

195. The determination of the extent of polishing of rice.

K. SRINIVASAN, A. R. VASUDEVAMURTHY and B. SANJIVA RAO, Bangalore.

Current methods of determining the extent of polishing of rice are reviewed. It is well known that there is a marked difference in the phosphorus content of the bran layers and the endosperm and that there is correlation between the phosphorus and the thiamin in "raw" rice. The amount of phosphorus present in rice is therefore a measure of its vitamin content and the degree of polishing of the cereal.

In the method developed in this laboratory one gram of rice is oxidised with nitric acid, followed by perchloric acid-sulphuric acid mixture, and the phosphorus is estimated colorimetrically by employing the molybdenum blue reaction. Results indicate that the method is very satisfactory for the determination of the extent of polishing of rice.

196. Low temperature gas producer.

G. RAMARAO, Belampally.

In the normal gas producer practice the fuel is raised to incandescence and the resulting gas is a mixture of CO and N_2 with a very low calorific value, and if steam is injected the gas is enriched with H_2 . The disadvantages of this type of gas producer are the restriction regarding the choice of a fuel whose ash should not clinker, the high temperature to which the lining is exposed to, and the low calorific value of the gas.

This paper describes the design of a new type of gas producer wherein a small part of the fuel is partially burnt and the rest of it is decomposed to give the products of low temperature carbonisation. The producer has a capacity of 700 lbs of coal. The yields of soft coke, the liquid bye products, and the gas are given. With a producer of this type any kind of coal or any other low grade fuel can be successfully used to give rich gas. In low temperature carbonisation practice this is called a semi-gas producer but the term is not quite an apt one.

197. Dyeing properties of Indian cottons.

D. L. SEN and NAZIR AHMAD, Bombay.

The dyeing properties of Indian cottons have been studied by using five important substantive dyes of varying molecular weights. Twelve varieties of Indian cottons were selected for this purpose and the samples were dyed under identical dyeing conditions in the raw state as well as after soda boiling, kierboiling and bleaching treatments.

The amount of dye in the spent dye liquor in each test was estimated by means of the photo-electric colorimeter designed in the laboratory, the details of which have been published in *Journal of the Indian Chemical Society (Industrial News edition)* June, 1938.

The following conclusions have been made from the above investigation.

Although the absorption of substantive dyes varies with the variety of cotton, the maximum variation is not large. The percentage dye absorption decreased as the fibre weight per inch increased, and is thus more in fine than in coarse cottons.

It was further observed that the dye absorption per unit length of cotton fibre increases with the increase in fibre weight of the cotton fibre.

The maximum dye absorption was found to decrease with increase in the molecular weight of the dyes.

Cottons in the raw condition were found to absorb more direct dyes than after treatments owing to the presence of polymers and waxes.

Among the treatments, dye absorption after soda boiling treatment, under normal pressure, is less than after kierboiling with alkali under high pressure.

198. Plastics at Bhadravati.

S. RANGA IYENGAR, Bhadravati.

A brief sketch of the manufacture of phenol-formaldehyde thermosetting plastics in an experimental pilot plant at Bhadravati is given. The process consists in condensation of phenol or cresol and formaldehyde in presence of catalyst ammonia under controlled conditions. The course of reaction is one of progressive polymerization of the initial condensation product called as "A" stage to successive "B" and "C" stages. "A" stage resin formed in the reaction is mixed with filler, dyestuffs lubricant accelerator and hardening agents in a ball mill. The mixture is passed on hot blanketing rolls to form a continuous sheet which is again ground to a granular powder. This forms the raw material for the moulder of thermosetting plastics. The industry is based on the fact that the resin is workable in stage "A" and by further heat treatment loses plasticity and passes on to the final infusible permanently hard state. One of the major raw materials Formalin has been made locally from C.P. Methanol obtained from Wood distillation. Hexamethylene tetramine an important ingredient for phenolic moulding compositions is also manufactured to meet requirements. Pilot plant for manufacture of furfural is working on a production basis. Experiments are under way to utilise Furfural for plastic purposes. Most of the equipment was fabricated locally and the plant is supplying one ton of moulding powder per month.

SECTION OF GEOLOGY AND GEOGRAPHY

PRESIDENT : H. CROOKSHANK, D.Sc.

1. A fossil tortoise (*Testudo leithii*) from the inter-trappeans of the Worli Hill, Bombay.

R. N. SUKHESWALA, Bombay.

The Worli Hill has claimed the attention of geologists from very early times, firstly for its geological features, and secondly on account of the fossils it has yielded.

Geologically it is constituted chiefly of the lava flows of the Deccan Trap age which are in turn underlain by thick sedimentary deposits of fresh water origin. These sedimentary beds are considered to belong to the highest inter-trappeans found in the Deccan Trap lava flows of Western India.

The Worli Hill has been and is still the source of the remains of fossil frogs (identified as *Indobatrachus pusillus* and *Indobatrachus trivialis*) of which skeletons, entire and broken, are still available. It was while collecting these frog samples that the specimen of the tortoise, *Testudo leithii*, was obtained from the black, compact, carbonaceous, hardened shale, occurring in the lower horizon of the hill.

Fossil *Testudo leithii* :— The specimen appears to be an impression of the carapace (probably internal aspect) of *Testudo* in its flattened state. It is almost oblong in shape and measures 8 inches in length along its central axis ; the maximum breadth is 6 inches.

Its preserved parts the marginals, the costals and the neurals are prominent and well preserved. Marginal scales are 18 while the costals are 7 in number. Three of the notches of the neurals are prominent. The specimen shows in its hind part two bold prominences with their surfaces curved. These surfaces are marked with a network of grooves which probably represent the horny part of the shell.

2. A morphometric study of the Damodar Basin.

SUBODH CHANDRA BOSE, Calcutta.

The Damodar Basin consists of a plateau in a submature state of dissection in its upper and middle parts, and a plain of deposition lower down. The sixty mile long and thousand foot high scarp edge of the Ranchi Plateau culminating in the peak of Khamarpat, the formidable gorge of Bokaro at Danea, and the imposing mass of Parasnath, are features which catch the casual traveller's eye most, but more important from the human point of view are the large, undulating erosional plains of Hazaribagh and Ramgarh, and the flood ravaged, alluvial flats in Bengal.

A land-slope analysis of the region reveals three facets, rough steeply inclined surfaces covering fifteen per cent of the basin, undulating lands covering thirtyseven per cent. and plains constituting the remainder. Hypsographic and clinographic curves drawn for the region show a convexity between 1000 and 1500 feet, indicating the preservation of a past erosional platform. A large block diagram of the basin has been drawn which vividly portrays these facts.

3. Notes on the felsite rocks near Markonahalli, Tumkur District.

Y. N. RAMA RAO, Bangalore.

Amidst the granitic gneisses in the vicinity of Markonahalli reservoir a group of dark felsitic rocks occur. The component types together with certain modified members range from vitrophyric to granophyric.

The felsitic rocks are products of consolidation from a highly acidic magma, and show signs of devitrification from an original glass. Subsequently these felsites have

been modified to certain hornblendic and gneissose types by a process of partial assimilation and metamorphism brought about by the later granitic magma.

These felsitic rocks differ in their mineral constituents and nature of alteration from the felsite rocks in Shimoga and Kolar Districts and are more acidic than the newer felsites associated with the Closepet granites. In the field relationship the Markonahalli felsite is distinctly older than the gneisses of the area, being in this respect similar to the older felsites of Shimoga District.

4. Density and patterns of population in the Lower Damodar Basin.

SUBODH CHANDRA BOSE, Calcutta.

Various causes leading to changes in population density in the area are considered. The great density found in the south east, though mainly agricultural, is also maintained by imported capital from the Calcutta conurbation, in exchange for services. The northwestern part has developed a great density in the past fifty years by the exploitation of coal and subsequent development of industry, resulting in some depopulation of neighbouring agricultural areas. Depopulation due to malaria is only slightly noticeable in the central parts.

Choropleths, isopleths and the dot method have been used to illustrate the above facts. Various patterns of population, both rural and urban, resulting from variety in topography as well as type of land utilization, have been studied.

5. The genesis of Deccan Traps.—a new theory.

N. S. JOSHI, Poona (London).

The paper describes the existing 2 theories of the formation of Deccan Traps. The first theory (generally accepted) traces the source of the lavas to the long fissures along the Konkan Coast and also along the east-west line—north of Nagpur. The second theory (not so well-known) supposes there were fissures all over the area now covered by Traps at distances of 5 to 50 miles, through which welled out huge lava flows. The paper describes the difficulties in accepting the former theory, viz. existence of 3 distinct horizons (described by the author in a previous paper) in each layer and the want of fossils in the middle traps. The untenability of the second theory is shown by the want of dykes in the Middle Traps.

The author puts forward a new theory, which traces the sources to the long fissures on the lines of the first theory, but does not agree that the lava flows were 60' thick individually and followed each other. The author's theory is that a very deep flow of lava (say 1000 to 3000') erupted suddenly and flowed over the surrounding country. The lavas cooled and thickened as they flowed, and lines of shear were formed inside them. This explains the existing 60' to 80' layers, the 3 horizons in each layer and the want of fossils.

The paper also describes how the latter theory goes to explain soil formations in Deccan.

6. On the origin of mica in pegmatites.

K. P. RODE, S. L. BISHNOI and R. S. SINGH, Dalmianagar.

During a visit to the area west of the Panchet Hill near Asansol in February, 1945 the authors came across a pegmatite vein partly worked, and apparently abandoned near the village Dhataria about 5 miles N.W. of Ramkanali, B. N. Ry.

A closer study of the material left on the surface shows the following striking features.

The fully developed mica crystals though roughly hexagonal in outline, had no equal sides, whereas the angles also showed some variations from the hexagonal angle of 60dg. The outline of the cleavage flakes resembles that of a typical monoclinic crystal like orthoclase parallel to (010).

Mica was found developed within feldspar crystals only, particularly along cleavage planes.

All gradations between specimens containing only quartz and feldspar and those containing only quartz and mica could be found. A closer examination of hand specimens discloses that the mica was not an original member of the pegmatite association

but that it developed as a result of post-pegmatitic hydrothermal alterations. Pegmatitic mica therefore does not appear to have any connection direct or indirect with the mica of the country rock as suggested by Holland and Fox.

7. Physiographic regions of the Panjab Plain.

KAZI S. AHMED, Lahore.

The paper deals at first with the general physical conditions of the Panjab Plain which is divided into four physiographic regions :—

- (i) The Northern Himalayan Sub-montane Regions ;
- (ii) The Eastern or Ghaggar Plain or the Sutlej-Jumna Divide ;
- (iii) The Central Plain or Sutlej-Jhelum Doubs ;
- (iv) Western Plain ; The Thal and Derajat.

The principal physiographic characteristics of each region are described.

8. On the albite schists occurring near Lingadhalli, Kadur District, Mysore State.

C. S. PICHAMUTHU, Bangalore.

This paper describes the chemical and petrographic characters of an interesting type of schist occurring about a mile south-east of Lingadhalli village ($13^{\circ} 36' : 75^{\circ} 51'$). The rock is greenish gray in colour with a very fine speckled appearance caused by white spots, which on microscopic examination are seen to be porphyroblasts of albite. The albites are mostly untwinned and occur in individual crystals or in clusters. They are set in a compact and matted aggregate of fibrous pale green chlorite. Sericite and some biotite are also present. Quartz is completely absent.

The rock has been chemically analysed and the percentages of the several constituents are as follows : SiO_2 39.12, Al_2O_3 23.17, Fe_2O_3 1.68, FeO 15.21, MgO 7.78, CaO 0.44, Na_2O 2.21, K_2O 2.46, TiO_2 1.06, MnO 0.18, H_2O 6.50, Total 99.81. It will be seen from this that silica is very low, alumina rather high, and lime is almost absent, while potash is slightly in excess over soda. The probable mode of origin of this rock is discussed.

9. Notes on Arab cartography from a study of the Arab Maps of Sind.

MANECK B. PUTHAWALA and ABDUL HAMID KHAN, Karachi.

Ancient maps such as those drawn by Arab geographers from the information derived by them from actual navigators and travellers, are neglected as first-class historical documents. They are very attractive, though not without inaccuracies, on account of their cartographical and decorative qualities.

For a study of the *geography of SIND under the Arabs*, the best available Arab maps have been assembled and classified by the authors as under :

- (1) Navigation charts, showing coastlines, ports, islands, etc.
- (2) Sketch maps, showing settlements, rivers, communication lines, products etc.
- (3) Maps, showing distances, Farsangs, stages and other measurements.
- (4) Maps, showing "Iklims" or zones, latitudes and longitudes.

The paper is illustrated with a number of interesting plans, sketches, and symbols, as part of a thesis in preparation.

10. On use-classification of Indian coals.

N. N. CHATTERJEE, Calcutta.

In this paper the author has made an attempt to put forward schemes for Use-classification of Indian coals for different purposes. The difference between the Scientific and Use-classification has been discussed in brief and the drawbacks of the Indian Coal Grading Board classification have also been pointed out. The principal uses of coal like coke making, gas manufacture and steam generation have been taken into account in this paper for evolving suitable schemes of classification. The analytical data (Proxi-

mate) together with the properties like sp.gr., caking index, calorific value etc. have been freely used and plotted in several triangular diagrams and graphs to bring out the characteristic features of the different varieties of Indian coals in a prominent way. A reference to the diagrams given in the paper shows that the schemes proposed might be of great help to the coal producers and consumers in the matter of final selection of coal for specific uses. The attention of the Coal Industry as well as of the country's Government has been drawn to the importance and utility of this subject of Use-classification and to the absolute necessity of proper utilisation of coal for the improvement of India's coal situation.

11. A geographical interpretation of the Mansura Loop.

MANECK B. PITHAWALLA and ABDUL HAMID KHAN, Karachi.

The formation of the island of Mansura (Arab Sind) was a curious phenomenon of nature, in which all Arab authors of the 10th and 11th centuries A.D. were extremely interested.

Major Raverty has entirely neglected the *geographical* aspect of this island, so highly spoken of by the Arabs, and has given a strange shape of the locality in the map in his book, showing the conditions of the country during the Arab times. His map is entirely different from the maps of the Arabs No. 1—12 given with this paper. Both the Arab authors and Major Raverty have, however, failed to put forth any scientific explanation of the formation of the Mansura loop, which was really due to the existence of an *ox bow lake* and its subsequent cut-off. The chief reasons for the existence of the capital towns, like Mansura and Bahmanabad on the island, were the water and trade facilities. With the change in the course of the river after the cut-off or avulsion the capital towns were ruined, and the island, the area of which has roughly been calculated as 63 square miles, was no more.

12. Occurrence of natural salts and selenite-gypsum in Lunkaransar, Bikaner State, Rajputana.

S. DEB, Calcutta and K. LAL, Bikaner.

Lunkaransar, a salt-lake, smaller than Didwana lake of Jodhpur State, is situated at a distance of 45 miles, N. N. W. of Bikaner city and lies on the railway line running from Bikaner to Bhatinda. The lake is elliptical in shape and covers about two square miles. During the rainy season water collects in the shallow depression of the lake and during the summer months it gets dried up, leaving the salts in the soil. It is estimated that approximately 5000 tons of salt can be obtained every year from this lake. A chemical separation of different salts (NaCl , Na_2SO_4 and Na_2CO_3) has been carried out in the laboratory. The proportion of these salts are almost similar to that of Didwana lake of Jodhpur State. Na_2SO_4 and Na_2CO_3 may be utilised in various industries either in the State or in the Punjab, which is not very far from this region. Considering the small amount of NaCl produced every year, it is not advisable to start a soda-ash manufacturing concern in this region, though cheap power might be obtained from Palana lignite, which is situated at a distance of about 30 to 32 miles from this place. Water scarcity is another reason against such a project.

The sub-soil of the Lunkaransar contains a rich deposit of selenite-gypsum. The gypsum crystals vary in size from $\frac{1}{4}$ inch to 7 to 8 inches. Detailed prospecting work was carried out in the region and about thirty (30) trial pits were dug to prove the extent and the quantity of the gypsum, as this is considered suitable for the manufacture of plaster of Paris. Gypsum is found associated with black-clay and "disappears" as this passes into arenaceous beds. Two isolated regions have been found in the lake which are proved to be rich in gypsum; the average thickness of the bed may be taken to be about 4 feet, and the gypsum content is about 40%. This gives approximately 500,000 tons of selenite-gypsum in this area.

13. The communal distribution of population in India.

GEORGE KURIYAN, Madras.

The paper gives a geographic interpretation of a few maps which have been drawn to show the actual distribution of population of each major community in India.

14. Contributions to the geology and geography of Karachi and its neighbourhood.

MANECK B. PITHAWALLA, Karachi and P. MARTIN KAYE, Korangi Creek.

In the present paper a study has been made of the rocks in the neighbourhood of Karachi, their nature, history, uscs, etc. The oldest strata belong to the Nari series of the Oligocene System and outcrop in the range of two hills (up to 750') trending N. E. from Cape Monze to the Mangho Pir region and thence northwards. These frequently fossiliferous sandstones and limestones are brought to the surface near a hot spring at the core of the denuded anticlinal valley in which Mangho Pir lies. The Gaj series of the Middle and Lower Miocene, underneath which the Nari rocks dip, are buff-coloured sandstones and limestones. They contain fossiliferous horizons and coral beds near Mangho Pir. Dipping under the Manchar rocks of the Lyari valley, they reappear in an elongated dome running from N.E. of Drigh Road to beyond Ghizri in the S.W. To the S.E. the Gaj rocks again dip under alluvium and Manchar sandstones. The Lower Pliocene and Upper Miocene rocks are largely unfossiliferous sandstones with occasional clay bands. At Ibrahim Haidari, however, two marine bands, packed with fossil fragments and sometimes bone remains, occur. One such horizon was also noted at the outlier beyond Ghizri. Manchar sandstones occur again at the Oyster Rocks and Manora islands. Capping these soft sandstones and protecting them is a tough conglomerate, a few feet thick containing fossils derived from older rocks probably of Pleistocene age. In addition to these solid deposits, superficial deposits are prominent in the water-bearing alluvia of the Lyari and Malir rivers. These include the wind-blown sands of the Clifton and Ghizri areas, the raised beach deposits of Clifton and Ibrahim Haidari and the vast eastward expanse of creek silts and muds, eventually blending into the delta of the Indus. The Middle Miocene folding is shown in the Gaj rocks. Late Pliocene and Pleistocene folding has influenced the Manchars and their conglomerate cover.

The problem of Karachi's water supply in relation to local sources was approached and it is considered likely that the deep bore at the junction of the Bazaar and the Malir rivers, carried only up to 800', did not reach the Nari sandstones, which are the strata most likely to yield a good supply. Recent alterations in land level, the nature of the landscapes, the problem of wind-blown sand and the nature of the silting process in the Keamari Harbour have also been noted.

The paper is accompanied with a revised geological map of the area, sections, microphotographs, etc.

15. Man and the Nepal Basin.

P. C. CHAKRAVARTI, Calcutta.

This mountain-girdled saucer-shaped depression, in the middle of the great Himalayas, maintains about one lakh of people. The secondary soils, heavy rainfall, manuring by sub soil black-earths, irrigation by open channels, terrace cultivation and hard manual labour are responsible for a yield of crops sufficient for the population. The basin has been, recently, urbanised in a modern way. Rivulets generate current, reservoirs supply water, and forests give fuels. Metalled roads, hospitals, a college and schools are a few of the basin's amenities.

Industrialists, businessmen, mineralogists and scientists would add wealth and prosperity to the area after the war, if facilities be given. This strategically important Hindu Kingdom might become a centre of trade and commerce and civilization for countries adjoining it.

16. Physiographic divisions of the Iran Plateau.

MANECK B. PITHAWALLA, Karachi.

The Iran plateau, including modern Iran, Afghanistan, Baluchistan and Makran, is an excellent example of a geographical unit. It has played a unique part in the pre-history and history of the Old World. It can also be called a clearing house of wares and cultures, as the old and the new have mingled here conveniently in the past. It lay on the historic route from the west to the east into India. It has given chances of nation-building to its peoples including the early Aryans for over 5000 years. Even its rocks, soils, mineral deposits, climates, flora and fauna are strange mixtures, rarely to be found in other parts of the world.

The cause of all this lies in geography, and in this paper an attempt has been made to present a physiographic division of the region as a preliminary to its study.

The method of division is the same as I have used for the Lower Indus Basin for my Sind researches, and subsequently also for the whole of India, Burma and Ceylon, and the purpose is to provide a homogeneous background of natural conditions, for workers in other fields, without which they are likely to make blunders.

Altogether I have shown in the Map drawn for this paper, 2 Major Divisions, 4 Provinces, 11 Sections and 28 Sub Sections.

Major Division	Province	Sections
(1) Highland Ring	I. Northern Folded Segment	A. The Elburz Mountains
		B. N. E. Kohistan
	II. Southern Plateau Segment	A. The Zagros Belt
		B. S. E. Arc C. Eastern Highlands
(2) Inland Drainage Areas	I. Inner Platforms	A. Khorassan Divide
		B. Seistan Divide
	II. Basins and Hamuns	A. Great Salt Desert
		B. Bampur Basin C. Seistan Basin D. Mashkel Basin

17. Note on the origin of the asbestos deposits of Manpur, and the petrology of the associated rocks.

S. C. CHATTERJEE, Patna.

The asbestos deposits of Manpur in the Dhalbhum subdivision of the Singhbhum district are associated with altered basic and ultrabasic rocks. The nature of the alteration, the origin of the asbestos and the petrography of the basic and the ultrabasic rocks as also of the acid rocks of the area are described in this paper.

18. Ilmenite rods exhibiting criss-cross arrangement from certain Cuddapah Basalts.

M. R. SRINIVASA RAO, Bangalore.

During the course of a detailed microscopic examination of the trap rocks of Cuddapah, the following interesting observation has been made. Certain varieties of traps occurring near Vempally are full of rods of ilmenite altering to leucoxene. These rods of ilmenite exhibit a most remarkable type of distribution in the rock suggestive of the well known criss-cross arrangement of labradorite feldspar in basalts. Such a structure developing out of ilmenite rods has not been reported so far. The paper discusses the significance of such structures.

19. A note on the occurrence of a Bowenite and Talc-Pierolite intergrowth in the Ultrabasic Rock from Holenarsipur area, Mysore State.

E. R. TIRUMALACHAR, Bangalore.

The paper describes the optical properties and chemical composition of Talc, Pierolite and Bowenite (massive Serpentine) from the ultrabasic rocks of Holenarsipur Schist Belt. The chemical composition of these minerals may be expressed as follows:—

Talc	$2\text{H}_2\text{O}, 3\text{MgO}, 4\text{SiO}_2$
Pierolite	$5\text{H}_2\text{O}, 9(\text{Fe}, \text{Mg})\text{O}, 7\text{SiO}_2$
Serpentine	$2\text{H}_2\text{O}, 3(\text{Mg}, \text{Fe})\text{O}, 2\text{SiO}_2$

The three minerals are intimately associated and there is a general transition of the massive Serpentine into Talc through the crystalline fibrous Pierolite. The massive Serpentine has a greater hardness than Pierolite and appears to correspond to Bowenite.

20. Algal structures from the Cuddapah limestones (Pre-Cambrian).

M. R. SRINIVASA RAO, Bangalore.

Recently the author had occasion to report on the occurrence of certain peculiar structures in limestones belonging to the lower Cuddapahs from Royalcheruv, Ananthapur district. Further work on the same material has revealed that they represent primitive plant life and are similar to the ones that have been described from America specially by Fenton.

They occur as nodules or stromatolitic bodies in the lower Cuddapah limestones. Their distribution in the field at a constant stratigraphical horizon suggests that they occur as reef building forms.

The rock shows numerous columnar bodies of calcium carbonate tapering at one end occurring either as free individuals and sometimes in groups, when they are fused together at the bottom by horizontal or curved extensions. They vary from 1 to $2\frac{1}{2}$ inches in diameter. In a transverse view on a polished surface of the rock, numerous irregularly concentric lines of growth can be seen. The whole structure reveals characteristic porcellanoidal patches suggestive of algal origin. The detailed paper includes a fuller description, comparison and photographs.

21. Geology of the Anorthosite belt, Salem District, Madras.

N. K. N. AIYENGAR and A.P. SUBRAMANIAM, Madras.

A belt of rocks characterised by the presence of basic felspar rock (anorthosite or anorthite gneiss) forms a curve, convex to the south, from near Pattalur ($11^{\circ} 16' : 77^{\circ} 48'$) on the banks of the Cauvery in the west to beyond Kottakkalpalaiyam ($11^{\circ} 16' : 78^{\circ} 1'$) in the east. Here it turns to the north and becomes split up into 2 or 3 bands. The total length of the belt is nearly 25 miles, and the average width some 200 feet.

The rocks composing the belt are biotite-gneiss, calc-gneiss, anorthosite and anorthite-gneiss, garnet-amphibolite and pyroxene-garnet rock, chromite-bearing amphibolite, granite and pegmatite. The anorthite-gneiss consists of a basic (calcic) felspar having a composition between labradorite and anorthite, actinolite, corundum (generally encased in a shell of calcite) and calc-silicates like garnet, chondrodite, zoisite and scapolite. The chromite-bearing amphibolite forms elongated lenses which are a few inches to 15 feet thick and contains anything up to 30 or 40 per cent (of its volume) of granular chromite. Granitic rocks have intimately penetrated the biotite gneisses (which form the country rocks) and have produced composite and banded gneisses.

The paper describes the rocks and their interrelationships in some detail.

22. Phlogopite in the Jeypore Zamindary in Viagapatam, Madras.

A. K. DEY, Calcutta.

Deposits of phlogopite near Kudia ($18^{\circ} 7' : 82^{\circ} 54'$), Majigudem ($18^{\circ} 12' : 82^{\circ} 54'$) and Borra ($18^{\circ} 17' : 83^{\circ} 3'$) in the Jeypore Zamindary in the Vizagapatam district, Madras, were investigated. The localities are on the Eastern Ghats and the area is underlain by a complex of garnetiferous sillimanite-schists, gneisses and -quartzites, and calc-gneisses, marbles, pyroxene-bearing rocks and granitic intrusives. Phlogopite occurs as irregular clusters or pockets in dyke-like or lens-shaped bodies of pyroxenite, which occur in close association with pyroxene-bearing gneisses, and frequently near calc-gneisses and marbles. The pyroxenite is usually much decomposed which makes the extraction of mica easy.

The mica is of fairly good quality and varies in colour from light amber to deep amber, sometimes with a greenish tinge. The largest specimen obtained measured about $1\frac{1}{2}$ ft. across. The minerals found associated with the mica include blue apatite and calcite. Although the phlogopite is capriciously distributed, yet at times it is found in such concentrated forms that a considerable quantity of it can be obtained from a single pocket. Some of the deposits were investigated superficially by pits and trenches, but the mica was found to decrease in size, and deteriorate in quality with depth. The economic possibilities of the deposits depend, therefore, on the persistence of 'books' of good quality underground.

23. Fossil cypræidae from the Quilon bed, Travancore State, S. India.

A. K. DEY, Calcutta.

The paper describes four new species—*Zoila schilderi*, *Cribraria quilonensis*, *Zonarina travancorica* and *Pseudozonaria simonneti* of the Family Cypræidae, from the Quilon bed exposed at Padappakara, seven miles north-east of Quilon, on the backwaters of the Asthamudi kayal in Travancore.

Cribraria quilonensis appears to be related to *Cypræa oincta* Martin from the Lower Miocene of Java.

24. Geology of Sandur State, Madras, with a note on Economic minerals,

P. S. NARAYANA, Bangalore.

Sandur State is situated between Latitudes $14^{\circ} 58'$ and $15^{\circ} 14'N.$ and Longitudes $76^{\circ} 21'$ and $76^{\circ} 44'E.$ in the heart of the Bellary district, Madras Presidency.

Most of the State is covered by Dharwars consisting of alternating schists, banded hematite-quartzites with contemporaneous trap beds, argillites, phyllites and slates. There are many basic and ultrabasic rocks such as picrites and epidiorites intrusive into the Dharwars. The traps of the area are similar to the Jogimearadi traps of Chitaldrug district, with conspicuous development of pyrites. The schistose rocks correspond mainly to the middle and upper Dharwars of the Mysore geologists. Many of the hills have a thick capping of laterite.

Regarding economic minerals, the author has noted for the first time the occurrence of native sulphur in the Donemeli region, nitre in the Balabhadra thattu and crystalline and high calcium limestone and kankar in the Chinnamavulasa region. Though minerals and ores of gold, copper, iron and manganese, together with several types of clay and ochre were reported in the past, several new finds have been recorded by the present author. Work is in progress to get the estimates of the reserves of many of these mineral deposits. The limestone is of very good quality with 50-53% CaO and the quantity available appears to be very large, MgO being between 0.5 and 1.5%. There are several iron and manganese ore deposits on the western as well as the eastern limbs of the synclinal fold of the hill ranges. The iron ores contain 60-68% Fe and the manganese ores 40-49% Mn. Manganiferous iron ores contain 40-45% Fe and 10-15% Mn. They are eminently suitable for development of an iron and steel industry. Good deposits of red and yellow ochres and white clays are easily available in the State.

The properties of the mineral spring water occurring in the various parts of the State are being studied.

25. A new form of range table for the graphical representation of heavy mineral analyses.

R. J. HAYMAN, Digboi.

The comparison of the heavy mineral contents of the Upper Tertiary rocks in Assam has provided a valuable aid to the determination of both the regional and local correlation. The method used by the geologists of the Burmah Oil Company is based on the recognition of mineral markers, of which the most important types are, (a) *Positive marker*, defined by the rapid increase in content of certain minerals at some horizon, or within a restricted zone, above which these minerals become much more common and continue to be so in higher horizons, and (b) *Negative marker*, characterized by a rapid decrease in frequency of minerals common in lower beds.

The successful application of this petrological method to correlation problems depends largely upon the readiness with which the available data can be compared, and graphical methods have proved to be by far the most suitable. In a paper presented at the Twentieth Indian Science Congress 1933, Messrs. Evans, Hayman and Majeed described such a method for the graphical representation of heavy mineral analyses, involving the construction of a 'mineral range table', in which the stratigraphical position of each sample (relative to some convenient datum) was plotted on the horizontal axis, and the frequency of each mineral, on an almost logarithmic scale, was shown on the vertical axis (a portion of which was allotted to each of the different minerals making up the heavy mineral suite of the sample). One disadvantage of this form of range table was its somewhat unwieldy size, being at least 18 inches in width; and efforts have since

been directed towards producing a more compact form, whilst at the same time retaining and incorporating the advantages of the original type of table. This has been accomplished by plotting in a special order and manner only those minerals of proved correlative value. These include Hornblende and Epidote, which are the most important, together with Garnet, and the two groups Staurolite-Kyanite, and Enstatite-Sillimanite-Andalusite. Three other minerals, Zoisite, Chloritoid, and Titanite, are also occasionally diagnostic. Variations in content of these eleven minerals, either alone or in combination, define all the mineral markers recognized in the Assam rock sequence.

In its new form the range table is much more compact, whilst changes in content of each of the diagnostic minerals (or groups of minerals) are displayed to the maximum advantage, with the result that all the mineral marker horizons are clearly defined. A thin strip giving the lithological details is also usually included, for experience has shown that confidence in the results will be greatly increased if the correlation deduced is based on the combined petrological and lithological evidences.

26. Problems of Baluchistan geology.

E. R. GEE, Calcutta.

Our knowledge of the stratigraphy of Baluchistan is mainly the result of the excellent field and palaeontological work of E. Vredenburg; in addition, the palaeontological work of F. Noetling and G. E. Pilgrim should be mentioned.

The writer during the course of economic investigations in that Agency in recent years has examined a number of isolated areas and acquired a fair knowledge of the general geology. He notes that the Baluchistan Agency appears to be divisible into three geological provinces—

1. The Eastern (Calcareous) province, including the hill tracts of eastern Baluchistan, composed mainly of calcareous and argillaceous sediments of Mesozoic and Eocene age and overlain in the foothills and alluvial-covered plains of the Sibi and Kachhi districts by Middle and Upper Tertiary sediments of the Nimadric suite. The rocks of this province were laid down in the Tethys and Indus gulf region, and continue northwards to link up with the sequence of the North-West Frontier Province and of the Punjab.

2. The Khojak-Mekran province including the thick Khojak Shales (Oligocene) in the north, forming the Khwaja Amran and northern Mekran ranges, overlain successively by higher Tertiary strata as the Arabian coast is approached. As Dr. E. Lehner has recently suggested [see *Proc. Nat. Acad. Sci. Ind.*, Vol. 14, Pt. 6, Section B, pp. 249-258 (1944)], this sequence appears to have been laid down in a marine basin separate from the Sind-Indus gulf.

3. The North-western (Chagai) province including Cretaceous, Eocene and Pliocene to Recent sediments with interbedded basic and ultra-basic lava-flows. Igneous intrusives of acid type, containing copper-ore in places, penetrate this sequence. In addition, in late Tertiary to Recent times volcanic activity gave rise to the Koh-i-Sultan and Koh-i-Taftan (in Persia) andesitic lavas, tuffs and agglomerates.

In the Chaman-Nushki area, the junction between the northern and the middle provinces is marked by an immense fault, the hade of which is very steeply inclined. The continuation of this structure to the south-west has not been studied in detail.

Thrusting, with 'Klippen' consisting of crushed Khirthar limestones resting on the Khojak Shales (Oligocene) in the area north and north-west of Quetta, also undoubtedly marks the boundary between the eastern and the middle provinces. The structure of this junction further south has yet to be examined in detail.

Many interesting problems in stratigraphy and tectonics await solution in this area and, on account of the excellent exposures, the region provides a great opportunity for original fieldwork in both stratigraphy and tectonics, the results of which will link up Indian geology with that of Afghanistan in the north and of eastern Persia and the Oman Peninsula (Arbia) to the west and south-west.

27. On the junction of the Shillong-series and the granite-gneiss on the Mairang-Lyngkhohi plateau, west-south-west of Shillong, Khasi Hills, Assam.

A. M. N. GHOSH, Calcutta.

The junction of the Shillong series and the granite-gneiss on the Mairang-Lyngkhohi plateau, west-south-west of Shillong, is of an eruptive nature. On the southern side on

the plateau thin bands of quartzite of the Shillong series are noticed along the foliation of the granite-gneiss and at one place the quartzite carries a wedge of the gneiss. On the eastern side of the plateau quartz-sericite-schists include along the cleavage planes narrow tongues of the gneissic-granite. Near the contact the direction of foliation of the granite-gneiss is more or less parallel to the direction of the major vertical joints of the quartzite as well as of the cleavage planes of the sericite-quartz-schists, suggesting that the gneiss and the Shillong series were subjected to the same orogenic movements. At places sericitic quartzites, near their junction with the granite-gneiss, carry bands of "pseudo-conglomerate" composed of flattened and elliptical pebbles of vein quartz given out by the granite. These suggest movements after the consolidation of the granite.

28. Preliminary notes on the Gneissic Complex of Nongmawit-Rambrai-Nongstoin Plateau, Khasi Hills, Assam.

A. M. N. GHOSH, Calcutta.

The western and the north-western portions of the Khasi Hills are occupied by a variety of para- and ortho-gneisses, presumably of Archaean age. The oldest members of the gneissic complex consist of fine-grained biotite-gneisses having either microcline or oligoclase as the dominant feldspar, biotite-hornblende-gneiss, biotite-cordierite-gneiss, biotite-cordierite-sillimanite-quartz-granulite with or without feldspar, and minor bands of calc-granulite, quartz-magnetite rock, sillimanite-quartz schist, sillimanite-corundum rock, and sapphirine-cordierite rock with green spinel. At several places segregations of sillimanite form workable deposits. The presence of such minerals as sillimanite, corundum, cordierite and sapphirine suggests very high grade metamorphism of pelitic sediments rich in alumina and magnesia. Intimately folded with the above gneisses are bands of basic rocks composed of hypersthene, diopside, hornblende and basic plagioclase. These rocks have developed both granulose as well as gneissose textures.

The gneissic complex is much intruded by several types of granites of different dates. The earlier granites appear to be leucocratic, fine-grained granulose aplites made up chiefly of quartz and alkali feldspars. Some of the aplites carry hypersthene, colourless augite, biotite and occasionally garnet. The later granites invariably carry biotite, are coarsely crystalline, and at places porphyritic in texture. Some of them have developed foliation and are gneissose, but there are others which are unfoliated and sometimes flow-banded. One such granite boss carries large-sized inclusions of olivine-gabbro, norite and picrite.

SECTION OF BOTANY

PRESIDENT : B. P. PAL, M.Sc., Ph.D., F.L.S.

Floristics and Taxonomy

1. The flora and some ecological aspects of the Krusadai island.

S. N. CHANDRASEKHARAN, S. V. PARTHASARATHY and D. DANIEL SUNDARAJ,
Coimbatore.

Krusadai Island is known to biologists for its richness in marine flora and fauna. Although much study had been carried out on the algal flora and the fauna, very little has been done on the equally interesting phanerogamic flora which is dealt with in this paper. The vegetation of the island is of special interest as it differs much from that of the mainland and the nearer bigger island Rameswarom. *Cordia subcordata* Lam. and *Suriana maritima* Linn. two species which are common in the far off Andaman and Nicobar Islands and which are reported to be strand plants in the coasts of Ceylon are also found here; it is surmised that these have been brought in here by the ocean currents.

The vegetation of the island is grouped according to their occurrence into the following regions :—(A) foreshore sandy region with the characteristic *Ipomaea* *Pescaparae* and *Spinifex* formations; (B) inland sandy region, separated from the former by a belt of marginal associations of a few trees and bushes followed by the closed grassland community; (C) salt marsh region dominated by the halophytic chenopodiales; (D) mangrove region with the dense growth of mangroves and (E) the marine region. Ecological descriptions on each of these groups have been furnished and a list of 148 species of flowering plants representing 46 families is also included.

2. The present position regarding the taxonomy of *Saccharum* and allied genera

N. L. DUTT and J. THULJARAM RAO, Coimbatore.

Opinion is divided even to-day regarding the relationship of *Saccharum* to allied genera. According to some, all the species of *Erianthus* should be transferred to *Saccharum* while others have reduced several species of *Saccharum* to *Erianthus*. The present conception of the genus *Saccharum* appears to favour its being split into (1) *Saccharum* L., (2) *Narenga*, Bor, and (3) *Sclerostachya*, A. Camus. According to Jeswiet the five species of *Saccharum* now are *S. officinarum*, *S. Barberi*, *S. spontaneum*, *S. sinense*, and *S. robustum*.

The Coimbatore Station already possesses one of the best existing collections of wild and cultivated *Saccharums* and a study is being made of the various forms. It is felt that to be satisfactory the study should include not only the morphology but anatomy and cytology also of the various forms. Similarly a study of the herbarium specimens alone is not sufficient.

India is quite rich in the various forms of *Saccharum* and allied genera. The Coimbatore Station is planning to organize an expedition to collect the various forms for an intensive study as also for assessing their value as breeding material. The Russian forms of *Erianthus* and *S. Spontaneum* as also the *spontaneums* from Uganda together with the forms from Java and Coimbatore have been studied. As far back as 1897 it was mentioned by Hooker that except the awned fourth glume he found no character to distinguish *Erianthus* from *Saccharum*. The awned fourth glume has quite recently been noticed in certain cultivated and wild forms of *Saccharum* in the collection at Coimbatore. But in no case are they exerted beyond the length of spikelet. The present position of *Saccharum* cannot be said to be a lasting one as a good many features still stand in need of intensive study.

3. On *Conocephalum supradecompositum* (Lindb.) st., a liverwort new to the Indian flora.

S. K. PANDE and D. C. BHARDWAJ, Lucknow.

In this note the authors describe the structure of [*Conocephalum supradecompositum*, a new member of the Marchantiales, previously recorded from China and Japan.

This liverwort is known to us only from the original description given by Lindberg (Acta Soc. F. Fl. fenn 11 No. 1884 as cited by Stephani) and the latin description by Stephani (Sp. Hep. 1, p.142, 1900). In this note, therefore, an effort has been made to give a detailed account of the plant.

The specimen was collected by Dr. P. Maheshwari in 1941, from a drain in Darjeeling. The thalli are repeatedly branched and bear numerous terminal and marginal, oval or elliptical subsessile gemmae covered with overlapping hyaline scales. The gemmae are easily detachable and contain abundant food material. The mid-rib is prominent and the thallus harbours a mycorrhiza. The specimen is sterile.

Embryology

4. Embryological studies in the Thymelaeaceae. II. *Daphne cannabina* Wall. and *Wickstroemia canescens* Meisn.

J. VENKATESWARLU, Guntur.

The structure and development of the anther, pollen, ovule, embryo-sac, endosperm, embryo and testa of *Daphne cannabina* and *Wickstroemia canescens* have been fully investigated. Further, a few observations on the pollen of *Edgeworthia Gardnerii* and on the pollen and embryo-sac of *Dirca palustris* are also included.

The anther development follows the normal course. The tapetum is parietal in origin and of secretory type. The mature pollen grain is 3-nucleate, with two elongated, spindle-shaped sperms. The exine has many germ pores and a reticulately marked surface. An exceptional pollen grain with two vegetative and two generative nuclei was also observed.

The haploid number of chromosomes both in *Daphne cannabina* and *Wickstroemia canescens*, as counted from the meiotic divisions in the P. M. C. is 9.

The ovule is anatropous and has two integuments. The inner integument forms the micropyle. A nucellar epidermal cap is formed. A conducting strand and hypostase are differentiated in the basal part of the nucellus. The primary archesporium is sub-epidermal and single-celled. Parietal tissue is formed. The tetrad is linear or T-shaped. In *Wickstroemia canescens*, it appears that sometimes the lower dyad directly forms the embryo-sac. Otherwise the development of the embryo-sac corresponds to the normal type. In *Daphne cannabina*, the number of antipodals is quite large; in *Wickstroemia canescens* 3-6.

A compact obturator is developed from the base of the style in both the species.

Embryo development agrees with that of *Thymelaea arvensis* already described by the author. It seems to follow the *Chenopodiaceae*-type.

The embryological features of the Thymelaeaceae agree a great deal with those of the Nyctaginaceae, while they differ in certain important points from those of the more typical families of the Myrtifloreae. Embryological studies, therefore, support the views of Hutchinson with regard to the systematic position of the Thymelaeaceae, who has placed this family along with Nyctaginaceae, Geissolomataceae, Penaeaceae in one order, Thymelaeales.

5. Female gametophyte and embryo in *Mimosa pudica* L.

S. G. NARASIMHACHAR, Bangalore.

Embryological studies in *Mimosa pudica* L. by the writer have revealed the following features. In the course of the development of the female gametophyte, the hypodermal archesporial cell cuts off two to three parietal cells. The megaspore mother cell which becomes deep seated forms a linear tetrad of megaspores of which the chalazal one is functional. The embryo-sac development conforms to the monosporic 8-nucleate type. The synergids are pyriform, and the polars remain without fusion till fertilization. In the course of the endosperm formation, the primary endosperm nucleus undergoes free nuclear divisions followed by wall formation only in the upper micropylar end. This results in the formation of a small coenocytic antipodal vesicle, which shows tendencies for ingrowth into the chalazal region. In the development of the embryo, there is no differentiation of a suspensor, the periclinal and anticlinal divisions of the zygote that follow give rise to a spherical embryonal mass.

6. Further contribution to the embryology of the genus *Osbeckia* Linn.

K. SUBRAMANYAM, Bangalore.

The present paper deals with the work on four species, *Osbeckia octandra* DC., *O. rosea* Fyson, *O. truncata* Don. and *O. Zeylanica* Willd. In the development of the microsporangium, five wall layers including the two middle layers are differentiated. A tapetal layer is well differentiated composed of uninucleate cells. The mature pollen grain is three nucleate, the tube nucleus being conspicuously enlarged. Chromosome numbers were determined for three species, the haploid number for them being 20 for *O. rosea*, 10 for *O. Zeylanica*, and 9 for *O. octandra*.

In the development of the female gametophyte, the archesporium is hypodermal cutting off parietal cells. Presence of multiple archesporium has also been noticed. Consequent to the formation of the massive parietal layers, the megaspore mother cell becomes deep seated. The occurrence of a zig-zag micropyle and a hypostase-like tissue at the chalaza are in conformity with the features noted by the writer for other species of *Osbeckia*. A linear row of tetrad of megaspores is formed of which, the chalazal one usually, or rarely in *O. rosea*, the micropylar one, develops further. A T-shaped tetrad is sometimes met with in *O. octandra*.

Endosperm is nuclear and the mature seeds are non-endospermic. After double fertilization, the primary endosperm nucleus undergoes free nuclear divisions, the nuclei showing tendencies for aggregations towards the chalazal end. The development of the embryo conforms to the *Capsella* type.

7. A contribution to the life history of *Sphenoclea zeylanica*, Gaertn.

K. SUBRAMANYAM, Bangalore.

The wall of the anther shows three layers below the epidermis. The endothecium is fibrillar and the tapetal cells are binucleate. The pollen grain at the time of shedding is tri-nucleate.

The semi-inferior ovary has numerous anatropous ovules on a massive axile entire placenta. The ovules are monotegumentary with the integument being thick and massive. The inner most layer during megasporogenesis forms an integumentary tapetum. Megasporogenesis proceeds normally and the embryo-sac is formed according to the monosporic eight-nucleate type. The synergids show pointed apices, with the nuclei situated in the centre. The antipodals are organised as definite cells. The two polars unite before fertilisation in the upper one-third region of the embryo-sac to form the secondary nucleus. Both syngamy and triple fusion occur as normal processes during fertilisation.

Endosperm is *ab initio* cellular. The endosperm develops haustoria at the micropylar and the chalazal end. Both the haustoria are four-celled, appearing as prominent lobes.

The embryo is formed according to the *Capsella*-type. A triangular cell is cut off and this functions as the hypophysis.

8. An embryological study of *Potamogeton perfoliatus* L.

D. M. GOPINATH, Bangalore.

Potamogeton perfoliatus L. is a common weed in the tanks around Bangalore, bearing a large number of flowers in the months of February-April.

The developmental stages of the male gametophyte was studied in detail. The occurrence of a tapetal plasmodium has been observed. The mature pollen is three-nucleate.

The development of the female gametophyte is according to the monosporic eight-nucleate type. The synergids are beaked. The synergids and the antipodals degenerate even before fertilization. The fusion nucleus is observed very conspicuously at the chalazal region of the embryo-sac. The egg is very small.

9. Development of female gametophyte in *Flacourtia cataphracta* Roxb. and *F. Ramontchi* Her.

D. M. GOPINATH, Bangalore.

A review of literature on the embryology of the Flacourtiaceae reveals the paucity of work on the family, and that no work has been done in India. The development of the female gametophyte in *F. cataphracta* and *F. Ramontchi* is presented in this paper.

The archesporium is hypodermal, cutting off a parietal cell. By further development the megaspore mother cell becomes deep seated. A linear tetrad of megaspore which in some cases becomes organized as a T-shaped tetrad is formed. Even at the

four-nucleate embryo sac stage, the micropylar end elongates, growing out of the nucellus. The egg apparatus is organized at the apex of this elongated embryo-sac portion. Development of more than one megaspore into double embryo-sacs has been noticed.

10. A comparative account of the development of endosperm in *Linum usitatissimum* (Flax) and *L. mysorens* Meyne.

D. M. GOPINATH and L. S. DORASAMI, Bangalore.

A study of the post-fertilization stages in 7 varieties of *Linum usitatissimum* (Flax) is made in comparison with *Linum mysorens*. The type of endosperm formation in *L. usitatissimum* is according to the Helobiales type as has already been reported by Schurhoff for the three species of *Linum*, viz., *L. perenne*, *L. flavum* and *L. usitatissimum*; he investigated. In contrast to this, the authors notice in *L. mysorens* a typical case of nuclear type of endosperm formation. *L. mysorens* is the only exception to the genus in having a nuclear type of endosperm formation.

11. The endosperm in *Hypericum mysorens*, Heyne.

B. G. L. SWAMY, Bangalore.

The primary endosperm nucleus in *Hypericum mysorens* Heyne., divides by free nuclear divisions. At about the eight-nucleate stage, a free endosperm nucleus moves up nearer to the zygote, accumulates dense plasma and starch grains; the nucleus divides into several free nuclei, all of which remain embedded in the plasma accumulation; this entire mass extends around the zygote and proembryo during their early stages in the form of an envelope but subsequently becomes mingled up with the general endosperm.

At about the sixteen-nucleate stage of the endosperm, an endosperm nucleus situated towards the chalaza gathers thick plasma and starch grains around; the quantity of plasma increases in bulk as the nucleus begins to multiply; all the nuclei (about 30) that result from the subsequent divisions are enclosed in the thickened plasma, which takes on the form of a cyst; the latter during maturity secretes a definite limiting membrane, so much so that it appears as a basal coenocytic endosperm cyst. This structure persists for a long time but finally degenerates.

It is suggested that the endosperm in *Hypericum* may be regarded as nuclear and its mode of development may be referred to as of the *Hypericum*-type.

Cytology and Genetics

12. Chromosome survey of *Saccharum spontaneum* L.

N. PARTHASARATHY and K. S. SUBBA RAO, Coimbatore.

So far only two forms of *S. spontaneum* species have been utilised for breeding sugarcane, with remarkable results. The nature of propagation, its high polyploidy, as also the polyploid nature of the wild species with which it has been crossed, would appear to be the main causes for the rapid progress in the obtaining of the economic types in sugarcane.

The multiplicity of forms of *S. spontaneum* and the existence of many more in unexplored areas indicate the wide range of material available for introducing specific characters as, resistance to disease, cold and drought, and quick growth, etc.,. The importance of *S. spontaneum* in sugarcane breeding is thus obvious and the necessity for an exhaustive collection and assembling of the wild forms and related species is stressed.

The chromosome numbers of twenty nine types of *S. spontaneum* collected from India and elsewhere, were determined. It is found that there is polyploidy within the species, accompanied with systematic differences, though a few aneuploid forms also are present. Among the Indian and the East Indian forms, the chromosome numbers indicate that forms with smaller numbers are found in North and North-West region of India and that the geographical trend of distribution is from North-West to South-East in respect of higher polyploid forms.

Certain discrepancies in the determination of chromosome numbers of the different forms of *S. spontaneum* are noted and it is pointed out that this may not be due to the method of propagation, viz., clonal, for the maintenance of these types. It is suggested that the discrepancies may be due to the crowded nature of the chromosomes in the somatic plates. The chromosome studies relating to the paper are mainly from the clear counts in pollen mother cells.

Difficulties in the classification of the various types, with reference to the morphological characters are met with, owing to the unreliability of many characters for taxonomic classification. The importance of cytology as an aid to taxonomy is discussed.

13. Cytological studies in the genus *Carica*.

L. S. S. KUMAR and V. K. SRINIVASAN, Poona.

This study is a continuation of an earlier investigation on the cytology of *Carica papaya*. The course of meiosis is traced in *C. dodecaphylla*. It is found that it is essentially similar to that already described in the case of *C. papaya*. Marked secondary association of the bivalents is recorded and on an analysis of 64 metaphase plates, it is found that the most frequent association is into eight groups: $1_{II} + 7_I$, while the maximum association is into five groups: $1_{III} + 2_{II} + 2_I$.

Meiosis is described in *C. pubescens* also. It is found to be similar to that in *C. dodecaphylla*. The phenomenon of secondary association is recorded here also and on an analysis of 57 metaphase plates, the same type of associations are met with both in the most frequent association as well as in the maximum association.

For the sake of comparison, the results of a re-investigation of the phenomenon of secondary association in *C. papaya* are given. These are closely similar to the data obtained in the other two species.

Since the maximum association in all the three species of *Carica* is into five groups, it is suggested that the primary basic chromosome number of the genus is five.

It is suggested that in the course of the evolution of the present-day *Carica* species with $2n = 18$ from ancestors with five haploid chromosomes, allo-tetraploidy and genic changes have played an important part.

14. Effect of x-ray irradiation on sugarcane.

L. S. DORASAMI and B. VENKOBÄ RAO, Bangalore.

Single eye-bud sets of local striped (Pattapatti) sugarcane were germinated and exposed to three different K. V. P., 65 K. V. P., 77 K. V. P., and 90 K. V. P. The milliamperage in the first two K. V. P. was 10 M.A. and 5 M.A. in 90 K.V.P. The distance of the object from the cathode was kept constant and the exposures varied. Irradiated eye-buds were planted in the field and their growth watched.

Analysis of the clumps indicated 48-50 percent variations. A series of bud variations producing pure yellow canes, striped canes and red canes from the same bud with various degrees of vigour very much superior to the check was recorded. The original red and yellow striped buds in some clumps gave rise either to pure greenish-yellow canes, or to canes which were striped at bottom and non-striped at top. Certain percentage of increase was noticed in the sugar content and irradiated canes flowered in contradistinction to the non-flowering check.

15. Some effects of x-rays on Co. 2.

L. S. DORASAMI and G. SRINIVASA IYENGER, Bangalore.

Germinated and non-germinated seeds of Cambodia 2 were exposed to x-rays for 5, 7½, 10, 15 and 30 minutes at a target distance of 6 inches using a current of 10 M.A. and 75 K.V.P. there was no effect observed on non-germinated seeds. Improvement of staple length (9 percent over the control) and yield (5 percent over the control) were observed and has been sustained throughout several generations. M.A. IX, outcome of this treatment, is grown on a bulk scale.

Irradiated pollen grains were dusted on the stigma of emasculated flowers and types obtained were not of any use economically.

Physiology

16. Further investigations on the vernalization of Indian wheats.

B. K. KAR, Calcutta.

Investigations were continued in four other strains of wheat, I.P.125, I.P.114, Pb.8A and Pb.C591, with a view to study the significance of the different phases, both thermal and photo, on the initiation of the reproductive stage. The following results were obtained.

1. Pre-sowing cold (6° to 8°C) treatment (vernalization) brought about an earliness of 5 days in I.P. 125; of 9 days in I.P. 114; of 8 days in Pb. 8A and of 5 days in Pb. C591, in the time of ear-emergence as compared with the untreated controls when both were grown under the local photoperiodic cycles of average 10 hours. light period alternating with 14 hrs. dark period.

2. The above noted earliness was enhanced to a great extent when the treated seedlings were grown under post-sowing photoperiodic cycles of 12 hrs. or more light period alternating with dark period of 12 hrs. or less.

3. A retardation in ear-emergence was induced if 24 hrs. continuous light period be alternated with 24 hrs. dark period.

4. From the above results it was concluded that (1) in these strains of wheat (as reported before in strains I.P.4; I.P.52; I.P.165) the thermal phase of low temperature followed by photophase of long day conditions was effective in inducing earliness, (2) the cold temperature vernalization seems to be associated with light periods tending towards long day cycles of over 12 hrs., (3) available light periods tending towards short day cycles (below 12 hrs.) were found to be unfavourable for cold temperature vernalization effect.

17. Investigations on the cause of early flowering in jute (*Corchorus olitorius*) sown in March.

J. C. SEN GUPTA and NIRAD KUMAR SEN, Calcutta.

It had been recorded that *Corchorus olitorius* (Chinsura green) when sown in March flowers very early in about 30 days as against the plants sown in mid-April to June which flower by the end of August to early September in 100 to 140 days. In the March-sown plants the vegetative growth is very much checked.

Some preliminary experiments to understand the causes of early flowering in March-sown plants were conducted. It has been found that growing plants in different degrees of water supply to the soil has no influence on flowering time. By moistening the plants by spraying water on the aerial parts twice and four times a day, no change in the flowering time could be brought about. Addition of ammonium sulphate to the soil was also found to be of no effect on flowering. By increasing the daily light period to 14 and 18 hrs. it was found that the flowering did not take place even after 3 months.

It seems that early flowering in March-sown plants is influenced by shortness of the light period prevailing in March, more than any other factor.

18. On the flowering on stock stem of mango grafts at nursery stage.

P. K. SEN, Sabour.

In a previous communication it was reported that flowering on the stock stem of mango grafts is sometimes seen in the nursery. While flowering on scion shoots which are obtained from mature trees is of common occurrence, flowering on stock stem which are only one to two years' old mango seedlings, is not common. A seedling mango does not usually flower before it is six to seven years old. It was suggested in the previous communication that the phenomenon may be the effect of the influence of the scion upon the stock, the favourable nutritional factors obtaining in the former being translocated into the latter. It was noted that in all cases where stock stems flowered, the scion shoots were also in flower.

In order to elucidate the conditions leading to flowering on stock stems certain experiments were conducted with one-year-old mango seedlings raised from seeds gathered from the fruits of a single tree. The treatments were (i) control, (ii) ringing of the seedling stem, (iii) inarching with similar seedlings as scions, (iv) inarching shoots of unringed branches of a mature tree, and (v) inarching with shoots or ringed branches of a mature tree. No flowering on seedling stems occurred in the cases of the first three treatments. In the case of treatments (iv) and (v) flowering on seedling stems occurred but under treatment (v) flowering was conspicuously increased both on scion and on stock stem, strengthening the hypothesis suggested in the communication above. It is however, still to be determined whether the C/N ratio alone or some other physiological factor or factors translocated from the scion are responsible for the phenomenon.

19. Studies in regeneration. Effect of different photoperiods on the regeneration of detached leaves

S. N. PATTANAIK, Cuttack.

In the present investigation, an attempt has been made to study the effect of different photoperiods upon the regeneration of Bryophyllum and Begonia leaves on a quantitative basis.

The complex process of regeneration seems to consist of more than one stage. In the first stage (which has been called initial developmental stage in this paper), the light inhibits the development of anlagen. In the second stage (which has been called regenerate formation stage in this paper) regenerates develop increasingly up to a critical light duration. Above the critical light duration, the process slows down and regeneration is inhibited. The effect of light in the initial stage of regeneration may, therefore,

be photo-chemical in nature, while in the second stage it may be photo-synthetic. No definite conclusion can be drawn at present regarding this aspect of the problem. The critical light period for regenerate formation seems to differ from plant to plant since *Bryophyllum* and *Begonia* behave differently in this respect.

Mycology and Pathology

20. Some fungicolous fungi.

M. J. THIRUMALACHAR, Bangalore.

In the course of the studies on the uredinicolous fungi in Mysore, the writer happened to collect a hyperparasite on *Santapauella heterophragmae* Thirumalachar & Mundkur (Mundkur & Thirumalachar 1945) which agreed very well with the descriptions of *Macrosporium Uredinis* Ell. & Barth. first described from North America on *Puccinia graminis*. In this studies on the uredinicolous fungi of Roumania, Hulea (1939) records *M. Uredinis* on the aecia of *Puccinia Violae* and on the uredia and telia of *P. Antirrhini* Wiltshire who made a detailed study of the foundation species of *Macrosporium* (1933 & 1938) pointed out that the genus should be merged with *Stemphylium* and partly with *Alternaria*. This procedure has been followed by numerous mycologists including Elliott (1917), Groves & Skolko (1944) and others. The hyperparasite parasitising the urediospores of *Santapauella heterophragmae* does not possess catenate spores and thus resembles the genus *Stemphylium*. This necessitates the proposal of a new combination for the accommodation of the fungus as *Stemphylium Uredinis* (Ell. & Barth.)

21. Soft rot of radish (*Raphanus sativus* L.)

G. S. VERMA, Lucknow.

Radish roots have been found to develop a rot in the fields during the rainy season, which is distinguishable by the peculiar offensive odour. A species of *Pythium* and two forms of bacteria were isolated. Pathogenicity experiments carried out variously have shown that *Pythium* is the causal organism whereas the bacteria thrive only saprophytically. The organism enters through wounds either on leaves, hypocotyl or root.

22. Latent infection in the mango fruit.

S. N. DAS GUPTA and R. S. BHATT, Lucknow.

The paper deals with the various aspects of latent infection in mango fruits. There are certain fungi which remain dormant in the fruits while growing on trees but act as active pathogens and cause rotting only when the fruits are brought to storage. Altogether 5 strains, *Aspergillus nidulans*, *A. niger*, *Acrothium* sp. 1.(AO), *Alternaria* Sp. 1.(A1) and *Fusarium* sp. 1.(F1) were isolated from fruits of all stages of maturity. *Fusarium* sp. was mainly isolated from young unfertilised ovaries or from fruits 3-5 mm. in length.

The correlation between the latent fungi, the fungi in the orchard atmosphere and those found on the surface of the fruits has been investigated.

The mode of infection, the mechanism and the nature of latent infection has been worked out in great detail for one fungus, *A. nidulans*. It has been shown that the fruits are most susceptible when they are about 70-80 mm. in length, the susceptibility gradually decreasing with advancement in maturity. The fungus, after getting an entry perennates in the form of a subcuticular hypha, resumes its growth a little before the fruits are picked and initiated the decay when brought to storage.

The paper also incorporates a discussion on the reaction of the various tissues of the fruits to the fungus in question, the absence of active parasitism during the early stages and the changes facilitating the advance and invasion by the organism at later stages of maturity.

23. A note on the infection of jute plants by Nematodes.

B. C. KUNDU, Calcutta.

During the course of our studies on jute it was found that in the plants raised at a particular spot of the garden of the Presidency College, the roots developed peculiar swellings and nodular or gall-like outgrowths. A study of the nodular outgrowths revealed that a certain species of nematode is responsible for bringing about this condition.

The infection was first observed in 1943 when about 60% of the plants were affected. In 1944 the infection also occurred in nearly 60% of the plants. In 1945 all the plants grown in the same plot were found to be infected. In 1943 and 1944 there had been no serious damage of the crop due to the nematode infection, although the growth of

the plant was checked to some extent. In 1945 the damage was very serious. All the plants of *Corchorus olitorius* were affected very badly from the beginning; they had stunted growth with poor development of leaves and all of them died before flowering. All the plants of *C. capsularis* grown in the same plot were also infected, but the damage was not very serious. They were also stunted in growth with poor leaf development; development of flowers was also very poor.

The internal structure of the stems and leaves of the infected plants was not changed; but the internal character of the root was appreciably changed. The nematodes are found at the inner portion of the cortex of the root towards the junction with the central cylinder. They lie in a mucilaginous covering during their early stage of entry and destroy the tissue where they live. There is usually considerable hypertrophy of the cells of the cortex with the production of a large number of giant cells. The formation of these giant cells causes swellings of the external tissues thus developing nodular outgrowths. The internal structure of the diseased roots has been described in the paper.

24. Observations on the leaf curl disease of the papaya (*Carica papaya* Linn).

P. K. SEN, Sabour.

A serious disease of the papaya beginning with the symptoms of etiolation and curling of leaves, and in advanced stages showing crippled leaves and fruits of various degrees and ultimately bringing about premature death of the plant has been observed. When the disease appears in a plantation, it often spreads all over. A similar disease of the papaya in Australia has been suspected to be of virus origin. In order to throw light upon its nature and to determine some practical method of control, certain experiments and observations have been carried out at Sabour, Bihar, showing that; (i) the disease can be produced in healthy plants by smearing them with sap of diseased ones; (ii) the disease is not borne through seeds; (iii) the disease can be produced in healthy plants by subjecting them to water-logged conditions, even without inoculation.

Miscellaneous

25. Parasitism of *Ximenia americana* L. Part 1.

L. N. RAO, Bangalore.

The root parasitism of *Ximenia americana* L. is described. There are two types of parasitism in *Ximenia*, parasitism on hosts other than itself and self-parasitism.

In self-parasitism there are two varieties, superficial ones being confined to the cortex of the host roots and deep-seated ones extending to the wood of the host.

26. Developmental studies : Origin and development of axillary buds with special reference to two dicotyledons.

G. P. MAJUMDAR and AMIYA DATTA, Calcutta.

Detailed studies on the initiation and development of axillary buds in *Heracleum* and *Leonurus* have been reported in this paper.

Work so far done on this problem in Ferns, Monocotyledons, and Dicotyledons has been briefly reviewed. In Ferns an axillary bud is initiated in the detached (apical meristem on the free surface of the axis or "in proximity to meristele conjunctions". In Monocotyledons initiation takes place in the surface layer of the corpus (Hsü, 1944) or in the subhypodermal layer of the apical meristem (Sharman, 1945), on the side opposite to the insertion of and in association with, the leaf primordium just above the one in whose axil the bud appears. Hence Hsü describes the origin as 'endogenous' in Monocotyledons. In Dicotyledons though Goebel reports origin from the embryonal meristem a little behind the free apex, Koch, Majumdar and Datta report origin in the vacuolating cells of the adaxial epidermis of the subtending leaf opposite the median bundle in *Syringa*, *Heracleum* and *Leonurus*.

In the shoot apices of Ferns, Monocotyledons and Dicotyledons leaf primordia are laid down first and buds are initiated in their axils later. A year may elapse between the laying down of the axillant leaf and formation of buds in their axils as reported in the winter buds of *Syringa*.

Bud trace originates in the bud primordium and then differentiates backwards to the leaf cushion outside the axial ring of vascular bundles, finally it enters the ring to unite with one of its sythetic bundles.

As the buds normally originate in the axils of leaves which are removed some distance from the apex and which are growing vigorously or unfolding, it is suggested that their initiation is due more to some physiological processes than to any specific qualities inherent in the apical meristem,

27. Notae Teratologici I

H. C. GOVINDU, C. S. VENKATESH and K. M. SAFEEULLA, Bangalore

The phenomenon of fasciation recorded in many plants has been attributed to the flow of superabundant nutrition, resulting in the formation of more than one primordium in close juxtaposition. In the course of these studies fasciation of shoots resulting in the flattening of the structure has been noticed in *Balanites Roxburghii* Planch., *Acacia leucophloea* Willd., *Alstonia scholaris* R. Br., *Crotalaria Juncea* L., and *Achras sapota* L.

Fasciation of flowers has been observed in *Olax Wightiana* Wall., *Nicotiana tabacum* L., and *Cordia* sp. and the fusion of pedicels followed by the coalescence of carpellary walls is noticed in *Heptapleurum venulosum* Seem. Peduncles of two separate inflorescences had fasciated in a stray specimen, *Aponogeton monostachyon* L., and the fusion of peduncles as well as those of inflorescence has been noted in *Artocarpus integrifolia* L.

28. Notae Teratologici II

C. S. VENKATESH and H. C. GOVINDU, Bangalore.

Leaf-bifurcation which has no particular phylogenetic significance has been noticed in the case of *Psidium guava* L., *Olax Wightiana* Wall., and *Memecylon umbellatum* Burm.

In two instances the phenomenon of phyllody was observed. In *Leucas aspera* Spreng., and *Rotala* sp. sterile leaf-like structures had replaced the florets. The exact cause for such a malformation is obscure.

Proliferation of carpels noticed as rare cases in *Citrus* and *Carica papaya* by other investigators is recorded in *Ficus carica*. Ascidium-formation has been seen in *Humboldtia unijuga* Bedd. As in all other cases of ascidium-formation, no phylogenetic significance can be attributed to this.

Occurrence of two fertile stamens in place of one has been observed in *Hedychium coronarium* Koenig, a member of the Zingiberaceae. In view of the new interpretation given by Raghavan (1941), for the labellum in *Alpinia calcarata* Roxb., based on floral anatomy and occasional presence of two fertile stamens, the present case of double stamens in *Hedychium coronarium* Koenig., may also prove interesting.

29. Intra-seasonal variation in the sizes of leaves and internodes.

C. V. KRISHNA IYENGAR, Mysore.

Of the many plants studied only *Asparagus racemosus*, *Codiaeum variegatum* and *Morus alba* are selected for this paper. Successive leaves, internodes and axillary branches of a seasonal shoot were studied and the oscillatory variation in their sizes recorded. This has revealed that there are variations not only from season to season but also from time to time within a season, these being almost rhythmic. The magnitude and frequency of these oscillations are highly pronounced during a period of great activity. It is often noticed that the longer internodes and heavier leaves and axillary branches often go together and are present about the middle of the seasonal shoot, signifying the greater vigour of this part. While the variation in the internal structure can be studied only from season to season the external structures have enabled the study of intra-seasonal variations even at intervals of a few days. The older branches have revealed the presence of four peak periods in the growth activity during a year. Since the seasonal variations leave an impression not only on the internal structure but also on the external parts it may be concluded that the oscillatory variation in size of parts during a season is indicative of the changing conditions for growth from time to time within the season, thereby making the seasonal shoot an efficient record of the changing growth-conditions even at intervals of a few days.

30. On hitherto unrecorded and unexpected by surprising effects of the caustic alkalis on the proteins of the pollen grains of Angiosperms.

N. K. TIWARY, Benares.

The paper records observations on the effect of treatment of the pollen grains with NaOH and KOH. It is found that after such treatment the contents of the pollen grains become stained differentially by aceto carmine, which otherwise fail to do so. It is further recorded that the results are better with increasing concentrations, including their saturated solutions. Both the chromatin of the nucleus as well as the cytoplasm do not appear to be affected adversely even after prolonged treatment.

31. Comparative studies on the differences in behaviour shown by the pollen grains and by the cells of the epidermis of the onion scale towards the action of caustic alkalis and pepsin-HCL.

N. K. TIWARY, Benares.

Experiments are recorded in this paper which show that the effect of the reagents in the two cases are almost diametrically opposed, and from this it is concluded that the cytoplasmic and nuclear components in the two cases are fundamentally different. These observations are recorded for the first time.

32. On a new use of cellophane as osmotic membrane.

N. K. TIWARY, Benares.

This note deals with the use of cellophane as a convenient and handy material highly satisfactory for demonstrating osmosis. Mention is also made of phials made of animal membranes in which hair-oils are supplied by the Indian dealers in the bazars, as other suitable material for demonstrating the same phenomenon.

33. A modification of Emmert's field method of estimating nitrate nitrogen in plant tissues.

P. J. DUBASH, Bombay.

Emmert's method consists in collecting the petiole tissue and immediately grinding it either with 2% acetic acid and charcoal or copper sulphate and calcium hydroxide as clarifying agents to remove all interfering tints. It is then evaporated to dryness, treated with phenol disulphonic acid and alkalisied with 30% sodium hydroxide solution. The resulting tints are then compared to permanent colour standards for estimations. This method is rough and requires a lot of chemicals and apparatus to be carried to the field.

The above method is now modified: as follows (1) the plant tissues are collected in liquid paraffin and then brought to the laboratory where they can be accurately analysed. The use of liquid paraffin prevents the loss of nitrates; (2) also ammonium hydroxide (1:2) is used instead of 30% sodium hydroxide as given in Harper's method, with satisfactory results; (3) the final estimations are carried out in the laboratory by the Dubose colorimeter which gives much more accurate results than by the original method.

34. A preliminary note on the phytoplankton of Bombay Harbour.

MRS. E. GONZALVES, Bombay.

The study of phytoplankton and its seasonal distribution is becoming increasingly important as these minute organisms are recognised as playing an important role in the food-chain of life in the sea. Consequently, they cannot be overlooked in any research on fisheries.

In this paper, the phytoplankton of the Bombay Harbour, recorded weekly over a period of a year is described. The chief forms belong to the Bacillariophyceae and the Dinophyceae. Silicoflagellates occur rarely. The period of maximum abundance coincides with the cold season (December-March). The hot season (April-May) shows a decline in the numbers while the monsoon season (June-September) shows a further fall leading almost to total disappearance of practically all forms in certain months. The appearance of new forms and a gradual increase in numbers starts from the end of September onwards. A comparison is made between these findings and those of workers from other parts of India. The probable causes of these seasonal fluctuations in numbers are discussed.

35. On the nature of corona in the passifloraceae.

V. PURI, Meerut.

Nine species belonging to four different sections of *Passiflora* have been studied in detail. The term corona is being used here in the widest sense to include all the series of threads, membranes, folds and scales intervening between the petals and the stamens. Following the English terminology used by Harms, the radii, the pali, and the operculum are regarded as outgrowths from inner surfaces of sepals and petals, and the limen is interpreted as staminodal in nature. These conclusions are based primarily on the vascular supply of the parts in question.

SECTION OF ZOOLOGY AND ENTOMOLOGY

PRESIDENT : PROF. M. A. MOGHE, M.A., M.Sc., Ph.D. (Lond.)

Cytology

1. Spermatogenesis of tortoise.

K. ZIA-UD-DIN, Lahore.

A study of the preparations, made with Flemming-without-acetic and Champy followed by 0.5% Iron-haematoxylin, reveals that the acrosome is formed by a few Golgi granules which have grown and fused together. The mitochondria remain very faint throughout spermatogenesis; and they place themselves in a spiral round the axial filament forming the middle-piece. After the distal centriole has taken its final position at the distal end of the middle-piece, the proximal centriole divides into two and both the products are placed at the base of the nucleus. The axial filament is short.

Spermatogonia and spermatocytes have also been studied in detail.

2. Acrosome formation in *Dysdercus cingulatus* (Fabr.).

HARBANS LALL, Lahore.

In view of the conflicting accounts of the morphology of the Golgi apparatus and the formation of the acrosome in Hemiptera-Heteroptera, the present work was undertaken in August, 1944. A thorough study of the preparations both fresh and fixed in Bouin, Flemming, F.W.A., Champy, Champy-Kull, Benda, DaFano, Cajal, Kolatchew and Mañin-Kopsch reveal that in the spermatogonium the mitochondria and the Golgi bodies are granular and massed together in the form of a cap to the nuclear membrane. During the growth period the mitochondria and the Golgi bodies become vesicular and show a duplex structure with a chromophilic cortex and a chromophobic interior. In the spermatid the mitochondria condense into a nebenkern which ultimately forms the sheath of the axial filament. The Golgi bodies fuse to form a spherical acroblast which appears as a ring in optical section. In the interior of the acroblast is differentiated a transparent vesicle, within which appears a small granule, the 'acrosomal granule'. This grows in size, becomes dense and comes out of the acroblast. The ring-like remnant of the acroblast is ultimately lost to view. The acrosome takes up an anterior position in the mature sperm head where it elongates into a lance-like apical piece.

Economic Zoology

3. Extraction of visceral oil from inland water fishes in the Collair Lake area, Madras.

P. I. CHACKO, Madras.

A cottage industry in the extraction of visceral oil from *Macrones gulosus*, *M. cavasius*, young *Labeo fimbriatus*, young *L. calbasu*, *Cirrhhina reba*, *Barbus sarana*, *B. sophore* and *B. ticto* exists among the fisher-folk living along the southwestern border of the Collair Lake. The viscera is treated by putting them with some water in flat mud pots placed over a slow steady fire for about one half hour. The food contents are not removed

from the intestine. Five pounds of visceral matter yield one pound of oil. The annual production is estimated to be 5000 pounds. The oil is yellowish in colour, and has a disagreeable smell. The oil has a Vitamin A potency of 50 to 330 International Units per gram, and an acid value of 31.14. It is used as food and for lighting purpose.

Physiology

4. Further observations on the osmoregulation of some Crustacea.

N. KESAVA PANIKKAR, Madras.

In continuation of the former studies on the osmoregulation of Crustacea (J.mar. Biol.Assoc.Vol.25,1941 & J.Exp.Biol.Vol.18,1941) *Orangon vulgaris*, the common shrimp and *Pandalus montagu*, the "Fleetwood Prawn" were investigated by the Hill thermo-electric technique. *Orangon* shows a tendency towards slight hypotonicity in normal sea water and a very pronounced hypertonic regulation in dilute sea water enabling it to withstand considerable variations in salinity of the external medium. *Pandalus* is isotonic in sea water; in dilute sea water, the hypertonic regulation is hardly developed at all and the species is consequently very sensitive to lowering of salinity.

The role of Calcium in the osmoregulation of *Palaemonetes varians* was examined and it was found that in Calcium free sea water the osmotic pressure of its blood rises considerably higher than its normal value of 2.2-2.4% NaCl. A similar behaviour was also observed in the common prawn *Leander serratus*.

The paper also gives the results of experiments showing the influence of Cyanide and Urethane on the osmoregulation of Palaemonid prawns.

5. Chemical and physical conditions in waters of the Bombay Harbour during 1944-45.

D. V. BAL, L. B. PRADHAN and MISS KUSUM GUPTA, Bombay.

The parallelism between the variations in the occurrence of phytoplankton and the available nutrient salts dissolved in the sea water has been so repeatedly established that it is now taken for a fact. A weekly analysis of a sample of sea water from the Bombay Harbour was made from July 1944 to June 1945. The chemical constituents determined were Salinity, pH, Phosphates, Silicates, Nitrites and Ammonia. The temperature and density of water were also recorded. In all 47 samples were analysed during this period.

The temperature of water fluctuated between 24°C and 30.5°C. The density varied from 10. to 10.25. The salinity was rather low during the rainy season (15th June to the end of September) and reached its minimum 23.56‰ in July and maximum 38.4‰ in the month of May 1945. The range of Hydrogen-ion-concentration was 7.90 to 8.35. The phosphates were found in quantities between 13.4 mg/m³ and 51.9 mg/m³. The lowest value for silicates was 344 mg/m³ and the highest 1953 mg/m³. The minimum and maximum quantities were 4.6 mg/m³ and 169 mg/m³ for nitrites and 8.3 mg/m³ and 156 mg/m³ for ammonia respectively.

6. Deinfestation and reclamation of insect infested foodgrains and flour by high temperature, short time process.

C. N. BHIMA RAO and V. SUBRAHMANYAN, Bangalore.

A method has been completely standardised for deinfestation of large quantities of stored foodgrains and milled products infested by the usual food pests, by the application of a system of flash heat treatment. The process briefly is to raise the temperature of the infested grains or flour to a temperature between 82°C. and 100°C. for three minutes and afterwards to screen the treated products through a proper mesh to remove the adhering webbs, the dust, the dead insects and their faecal pellets. The treated grain or flour retains all its original characteristics. All the insects and their eggs are instantaneously killed at the temperature. Experiments made on about 3000 bags-full of different foodgrains show nearly 100% kill of insects and their eggs. Appropriate periods of observation show no emergence of live insects. Between 50 and 90% of the original material have been reclaimed from heavily infested foodgrains.

The milling and baking qualities, germinating capacity and nutritive value of the grains are unaffected by the process. In cases of good quality wheat, slight improvement is noticed in the milling, baking and cooking qualities.

A suitable heat treatment machine has been devised and a small one to deal with moderate quantities of foodgrains and flour has been manufactured on the principle of the contact heater type apparatus for installation in one of the mills.

Reduction between 3 to 4% moisture aids in the storing quality of the foodgrains after deinfestation and improves milling characteristics of wet poor milling grains. Reclaimed foodgrains have kept free from appreciable infestation between 3 and 10 months when stored under hygienic conditions.

7. Marginal survey of Hosainsagar.

A. K. DAS and VALI HYDER HOSAINI, Hyderabad.

Observations were made during the months of February and March 1945. The main items were pH, temperature and types of fishes.

It has been shown that the water of this reservoir was always on the alkaline side as is usually the case with the waters of other tanks in the State.

Further work is in progress which will include besides these items, the types of vegetation and analysis of water at different seasons of the year.

8. Functions of the blood and coelomic fluid in the earthworm.

K. N. BAHL, Lucknow.

It is commonly believed that the blood of an earthworm is only a solution of haemoglobin and serves merely as a carrier of oxygen, while the coelomic fluid is a carrier of (a) food-materials to the various parts of the body and (b) metabolic wastes to the nephridia for elimination. Biochemical estimations of various nutritive and excretory substances in the blood and coelomic fluid have shown that while blood has both nutritive and excretory functions, coelomic fluid has no nutritive function at all. It does, however, share the excretory function with the blood.

Technique

9. On the preparation of a vertebrate skeleton.

M. L. BHATIA, Lucknow.

Ordinary method employed in the laboratories for making a skeleton is to remove the attached muscles by boiling the animal in water. This surely damages the cartilages as well as other delicate parts of the skeleton.

Skeletons are best prepared from fresh material. It is a difficult task to prepare good skeletons from specimens that have been preserved in formalin. In order to prepare a complete skeleton remove the skin, all the viscera, and as much of the muscles as possible and soak the specimen in water. The remaining muscles will decay and may be removed with the forceps. This process of maceration takes more time in cold weather and to hasten the process the specimen may be immersed for a few hours in hot water to which some soap has been added. Kingley's formula gives good result :

Hard soap 75 gms., Potassium nitrate 12 gms., strong ammonia 150 cc. Distilled water 2000 cc.

The length of the time required before the muscles will separate from the bones varies with the different animals. It is required to keep all the delicate cartilages intact, the skeleton should not of course, be boiled, but treated with moderately hot water. Maceration in water for a long period will help in detaching the investing bones.

For making museum preparations, dip the skeleton prepared by the above given method in a weak solution of methylene blue. Treatment with weak acid-water (HCl) will differentiate and brighten the stain on the cartilages. Preserve the stained skeleton in weak formalin (5 to 10%) to which some glycerine is also added.

Helminthes

10. On a new Trematode *Neoprosoerhynchus purius* N.Gen., N.Sp. from the intestine of a fish *Epinephelus lanceolatus* (Bl.).

J. DAYAL, Lucknow.

The new form *Neoprosoerhynchus purius* N. Gen., N. Sp. belongs to the family Bucephalidae and resembles the genera *Prosoerhynchus* and *Pseudoprosoerhynchus* in the structure of the rostellum, but differs from them in the relative position of testes, ovary, vitelline glands and in the possession of Y-shaped excretory bladder. A detailed account of the new form is given in the paper.

11. *Clinostomum kalappahi* n.sp. (Trematoda) from the mouth of cats in the Coorg.

G. D. BHALERAO, Izatnagar.

The new species differs from all the existing species of the genus in the following respects :— (1) The collar at the anterior end not being in the form of a continuous ring but having its ends juxtaposed ventrally, (2) the anterior testis is U-shaped, (3) the genital pore is situated posterior to the cirrus sac, ventrally to the anterior testis and (4) the central portion of the body anterior to the ventral sucker is crowded with non-cellular glands. The parasites are found under the tongue and are also attached to the walls of the buccal cavity. A detailed description of the parasite is given and its affinities are discussed.

12. Intermediate hosts of *Dicrocoelium dendriticum* in India.

G. D. BHALERAO, Izatnagar.

Under the scheme of helminthiasis of the Imperial Council of Agricultural Research running at the Imperial Veterinary Research Institute it has been determined experimentally that the commonest land mollusc in the Kumaon Hills, *Macrochlamys (Euaustenia) cassida*, serves as the intermediate host of the lancet fluke, *Dicrocoelium dendriticum*. The writer in 1930 had come across some naturally infected specimens of *Macrochlamys (Euaustenia) monticola* with the larval forms of the lancet fluke. They harboured the tubular sporocysts containing the typical *Cercaria vitrina*. It thus appears that at least two species of *Macrochlamys* serve as the intermediaries of the lancet fluke in the Kumaon Hills. The distribution of this fluke in India, so far as is known, is restricted to the Hills of the Northern India. Future investigations will reveal whether some other species of land snails act as intermediaries of this fluke in different hills of the Northern India. It will also be worth while to search for this fluke in the Western Ghats and in the hills of the Southern India.

Some remarks are offered on the structure of the sporocysts and that of the typical cercaria.

13. On the life-history of *Trichuris ovis*.

P. G. DEO, Izatnagar.

Trichuris ovis occurs very commonly in domestic animals all over the world. When present in large numbers, they cause digestive disturbances and produce local haemorrhage. It is surprising that inspite of its common occurrence no attempt has yet been made to elucidate its life-history. Experiments were therefore undertaken to work out the life-history of this whip-worm. Fertilised eggs were recovered from gravid females obtained from a sheep and were cultured in different media. It was found that aerated distilled water acts as the best medium for the development of eggs. They are fully embryonated between 13 to 15 days and the embryos are seen moving actively inside the egg-shells. Such embryonated eggs were fed to a clean lamb which was kept muzzled throughout the experimental period and was fed only on milk and tree leaves. The animal was found dead fifty days after the infection. Post-mortem examination revealed 4 immature worms in the stomach and 685 immature worms in the small intestine. Attempts to induce the larvae to hatch in culture media proved futile, although the observations were extended over a period of four months. After about six weeks the embryo inside the egg-shells became inactive,

14. Blood flukes infection (schistosomiasis) in the Cattle, Goats and Sheep of the Central Provinces and Berar and Central India.

M. A. MOGHE, Nagpur and B. S. CHAUHAN, Benares.

This paper deals with a survey of the blood flukes parasites of the genus, *Schistosoma* Weinland from Cattle, Goats and Sheep of this area. Observations, on the degree of infestation and the seasonal and regional variations have been recorded. The authors are of the opinion that C.P. and Berar, is the most heavily infected part of India from these parasites and therefore suggest that necessary experimental work should be undertaken and measures devised to eradicate them. This is specially necessary as one of these flukes is known to cause the "Snoring disease" (*nasal granuloma*) of the cattle, a disease peculiar to India and Ceylon and as outbreaks of *Schistosomiasis* are reported to occur even in epidemic form, particularly in Bihar and Orissa. Workers in other parts of India report that they are unable to undertake work on the life history and biological control of these flukes for want of necessary material.

Polyzoa

15. *Urnatella indica*, sp. nov.

R. V. SESHAIYA, Annamalaiagar.

The only representative in freshwater of the Entoprocta is *Urnatella*. Till recently, *Urnatella* was only found in North America and represented by a single species *Urnatella gracilis* Leidy. Sometime back the author of this note reported the occurrence of a freshwater Entoproctan Polyzoan in Annamalaiagar, South India. This belongs to the genus *Urnatella* and is now described as a new species *Urnatella indica*. It differs from *Urnatella gracilis* in the mode of the origin of the stalks from the basal disc, in the number of segments in the stalk and in the number of the tentacles of the polyps. In *Urnatella gracilis*, the North American species, the gonad is represented by the testis only, and no trace of the ovary is said to occur. But in *Urnatella indica* the gonads are very large, and distinct ova are found in the gonad besides developing sperms. The animal is therefore hermaphrodite.

Annelida

16. The eyes of polychaetes.

P. R. SADASIVAN TAMPI, Madras.

The eyes of six Polychaetes from Indian Waters, *Eunice aphroditis*, *Murphysa gravey*, *Lycaeus indica*, *Perinereis aibuhitensis*, *Tomopteris* sp. and *Dasychone cingulata*, belonging to four different families have been investigated with special emphasis on the nature of the refractive bodies and the retina. In *E. aphroditis* (Family Eunicidae) the eyes are well developed; the refractive body is derived from the cuticle and is connected with it. The glass-body usually found between the lens and the retina in other annelids is almost absent in this species. The retina is composed of sensitive cells with rods at their inner ends, and of supporting cells with their supporting fibres. *M. gravey* which belongs to the same family has a highly reduced eye in the adult condition, which may be correlated with its burrowing mode of life. There are two pairs of eyes in both *L. indica* and *P. aibuhitensis* (Family Nereidae). The refractive bodies in these are more or less similar in structure to the glass-bodies and they do not show any connection with the cuticle. In *Tomopteris* (Family Tomopteridae) which is pelagic, the eyes show an intermediate structure between that of Spionidae and the higher Nereidae or Syllidae. In the Sabellid *D. cingulata*, the structure is very different and shows a primitive type of compound eyes of the nature of faceted eyes bringing about a simple form of mosaic vision. The eyes in three larval types have been studied and they show a simple structure consisting of mere pigment cups sunk in the brain mass.

This comparative study lends additional evidence to the general conclusion that the structure and formation of the eyes in the different groups of Polychaetes are fundamentally the same.

17. *Limnatis nilotica*, a leech causing Laryngo-pharyngitis in man.

M. L. BHATIA, Lucknow.

Parasitism by leeches in the pharynx, larynx and adjacent cavities in man is recorded from different places by a number of workers; and also from India by the author

(1941 Proceedings of the Indian Science Congress). *L. nilotica* occurs in fresh water pools and normally feeds on frogs attaching itself to the surface of their body and whenever possible, on cattle and also in man. In the latter case the leeches enter the mouth during drinking and usually attach themselves to the larynx. Once established in the throat, a leech may remain there for two months or even longer, changing its place of attachment from time to time. G. Witenberg, from Hebrew University, Jerusalem writes, "Leeches of the species *Limnatis nilotica* are the most common cause of Laryngopharyngitis in man."

While in the throat the leech may cause congestion of the surrounding tissue and bleeding which may sometimes be profuse but without any pain. The congestion is caused by substance producing hyperemia, and the bleeding by *hirudin* which the leech injects into the wound in order to prevent clotting of the blood.

A leech may easily be removed from the throat if after it has been taken by forceps, some irritant substance is applied to it (50% Acetic acid, Trichloroacetic acid, powdered salt, or strong salt solution etc.). Strong solution of cocain has also been recommended for application in order to anesthetize the leech (Witenberg).

Insecta

18. Studies on the bionomics of *Eupterote testacea* Wlk.

G. RENGALAIYAR, Trivandrum.

The paper gives a detailed account of one of the less important hairy caterpillar pests of cardamom in Travancore.

During the south west monsoon in June and July eggs are laid in clusters on the underside of the leaves of *Erythrina indica* Lam. A single female lays about 300-350 eggs in 8 to 9 days. The incubation period lasts for 13-15 days. Newly hatched caterpillar is 2.5 mm. long with a head width of 0.5 mm. The caterpillars are gregarious and feeding begins late in the second day. There are seven instars in a larval life of about 96 days. They are found on cardamom from the 4th instar. The caterpillars pupate in the soil 1-1½ inches deep within a silken cocoon to which soil, debris and short urticating hairs adhere. The pupal duration is 7-8 months.

The caterpillars have been found feeding on *Dolichos lablab* Linn. and *Polygonum chinenses* Linn.

19. Note on life history and habits of Castor-semiloopers.

MOHAMMAD QADIRUDDIN KHAN, Hyderabad-Dn.

The caterpillars of the moths *Achaea janta* L. and *Paralellia algira* L. are serious pests of Castor in the Hyderabad Dominions. The eggs of the moths are generally found in the second week of May on perennial Castor. Caterpillars in all stages of growth are found in the first week of June. July and August are months of activity, when 4 to 5 eggs are found on each castor-leaf. In August, September and October outbreaks of the pest are quite common in the Castor-growing areas. From November onwards the activity of the pest decreases, and no serious outbreaks occur.

Five to six generations of the pest pass in a year in the State.

Detailed life-history studies of *Achaea* and *Paralellia* have been made, and it has been noticed that the total developmental period is shorter in June, July and August lasting only for about 28 days in *Achaea*, and 31 days in *Paralellia*. From October this period increases, and in February and March it is about 47 days in *Achaea*, and 49 days in *Paralellia*.

Alternate host plants noted are rose, pomegranate, *Bauhinia* sp. *Ziziphus*, *Ficus benghalensis*, and *Euphorbia tiliuifera*.

The eggs of *Achaea* and *Paralellia* moths are heavily parasitised in the fields by *Trichogramma evanescens*, Westw. (race minutum Riley). The percentage of parasitisation of eggs ranges from 44.4 to 100, highest being in August. The larval parasites observed are *Microplitis maculipennis*, *Rhogus* sp. and *Euplectrus* sp.

20. The Cardamom Lasiocampid, *Lenodora vittata* Wlk.

G. RENGALAIYAR, Trivandrum.

The caterpillar of this moth is a voracious feeder and causes heavy defoliation of cardamom. It is not yet considered as a major pest since it occurs only in widely scattered patches. A detailed account of the life history and habits of the pest in Travancore is given in the paper.

During June-July eggs are laid on cardamom leaves. Oviposition which commences one or two days after emergence continues for a period ranging from 6-9 days and a female lays in all about 100-130 eggs. The incubation period lasts for 10-13 days. The newly hatched caterpillar has a length of about 7.3 mm and a head width of 1.4 mm. The egg shell is completely eaten. Feeding begins on the 3rd day. There are six instars in the larval stage extending over a period of about 120 days. The full grown caterpillar is about 110 mm. long with a head width of 6 mm. Pupation takes place in the soil 2-2½ inches deep without a cocoon. The pupal duration is 5-7 months.

The caterpillar is attacked by a Tachinid parasite, *Carcelia kockiana*. Large numbers of a small reddish mite have also been found on them.

21. Incidence of sugarcane borers during different times of a year at Gwalior.

R. RAKSHPAL, Gwalior.

Incidence of borer attack on sugarcane sown on different dates, viz., on the 20th of each of the months of January, February, March, and April has been studied during the years 1942-43, 1943-44, and 1944-45. It has been observed that *Scirpophaga* usually appears in August, goes on increasing, reaches its maximum in December-January and later on declines. *Immalocera*, *Argyria* and *Sesamia* appear in May-June, go on increasing, reach their maximum in July-August, later on continue declining and usually remain absent during the later part of the sugarcane season.

Yield of sugarcane, percentage of borer attack and the juice analysis show that the first week of February is the ideal period for sugarcane sowing in Gwalior State.

22. Light trap studies in relation to the control of the Paddy stem borer *Schoenobius incertellus*.

M. C. CHERIAN and K. P. ANANTHANARAYANA IYER, Coimbatore.

This paper deals with the observations on the light trap trials conducted for the control of the Paddy Stem borer (*Schoenobius incertellus*) during the past 5 years. While the light trap has been advocated by many writers as one of the methods of control, there are practically no detailed records relating to systematic field scale trials. The data presented show the utility of the light trap for reducing infestation in crop. Apart from the Petromax, even an ordinary Hurricane light, can be used with advantage. Moths marked with silver gilt dust, and released at distances have been recaptured at light showing so far, a flight range of 150 yards towards Hurricane light and 200 yards towards a 200 candle power Petromax light.

23. Trials with insecticidal dusts for the control of the potato tuber moth in stores.

M. C. CHERIAN and C. V. SUNDARAM, Coimbatore.

The potato tuber moth-*Phthorimaea operculella* is a serious pest of stored potatoes in the hill regions especially the Nilgiris. The results of application of dusts such as tobacco, derris, pyrethrum and *Acorus calamus* to control the pest are discussed.

24. On the biology of *Danaus chrysippus* (Linnaeus)

D. MUKERJI and BASANTA KUMAR BEHURA, Calcutta.

In this paper the life-history of the common 'plain tiger' butterfly, *Danaus chrysippus* (Linn.) is studied. The eggs of this insect are usually laid singly on the under-side of the food plant *Calotropis gigantea* R.Br. The authors also noticed the eggs on the adaxial side of the leaves as well as on the stem of the food plant.

The larvae of this butterfly usually feed on the leaves of the food plant but occasionally a few flower-eating forms also occur. These differ slightly from the leaf-eating specimens in colouration.

Five colours of dichroic pupal colours were noticed viz., green pale and deep pink pale and deep, and yellow pale.

Trichogrammatids (Chalcidae) were noticed parasitizing the eggs and a Tachinid fly was found emerging out of the pupa. Parasitization by the Tachinid fly also appears to have occurred at the egg stage of the host.

25. The tracheal system of *Galerucella birmanica* (Jacoby) a Coleopterid insect on the Singhara leaf.

S. M. HUSAIN KHATIB, Nagpur.

The author has worked out complete morphology, internal and external, of this interesting pest on the Singhara leaf. After a careful review of the existing literature he has come to the conclusion that the tracheal system of this insect, in fact of the entire sub-family Galerucinae has not been worked out in any great detail. In this paper the author describes the tracheal system in all its aspects.

The number and arrangement of spiracles in this beetle partly confirms the theory recently put forward by Keilin (Parasitology, 36, 1944) as to the primitive position of spiracles in insects.

26. *Dermestes vulpinus* Fabr. an insect pest on dried fish.

S. T. MOSES, Baroda.

The Bombay Duck and Prawn fisheries of the Baroda State—History of the investigation into insect pests on Dried Fish—The pests attacking dried fish. *Dermestes*, 2 spp. of *Neorobia*, 2 mites and an Aphid.—Habitat of *Dermestes vulpinus*—Appearance—Reproduction—Habits—Store-houses and Containers—Dr Pruthi's suggestions—Dr. Ramakrishna Ayyar's suggestions—other suggestions—Use of poisons dangerous and so unsuitable—Handpicking of beetles and grubs useful but indifference to quality and sentiment against destroying life have to be overcome—Infected stuff can be cleaned by exposure to sun or artificial super heat—Dry fish kept in clean large pots with lids and placed on high platforms in clean rooms are safe—Summary of measures to be adopted.

27. The egg and triungulin stages of *Mylabris pustulata* Th.

K. KARBUNAKARAN NAYAR, Trivandrum.

Mylabris pustulata Th. (Meloidae: Coleoptera) shows hypermetamorphosis, The paper describes the egg and the first stage (Triungulin) larva of the beetle.

Eggs were obtained in March, and are elongated, white, oval objects, with a faint curvature in the middle, and pointed towards one end. The opposite end is broadly rounded and forms the anterior end of the embryo. The egg on an average measures 2 mm. in length and 0.54 mm. across. The incubation period varies from 15 to 18 days.

The flattened triungulin is an active whitish larva which turns soil brown in a day or two. Head with two large, black eye spots; a pair of three-jointed antennae with a knob-like sense organ in the second joint; triangular, setaceous labrum; long, curved, and pointed mandibles; sickle-shaped lacinia; and biarticulated labial palps. Thorax of three segments each with two dorsal, transverse rows of setae. Legs long, with setaceous tibiae and one segmented tarsi provided with long, paired stiff setae. Abdomen nine segmented, the last segment smallest, bearing a pair of long setae. Spiracles are rounded.

28. *Tribolium castaneum*, an important pest of malt food and its control.

M. C. CHERIAN and T. V. SUBRAMANIAM, Coimbatore.

Tribolium Castaneum is the most important pest of Sorghum malt. Both adults and grubs feed on the malt food. In the case of malt, fumigation is not feasible. Studies on other control methods have shown that heat treatment—55°C for 10 minutes is effective in killing all the stages of the pest. The effect of Co₂ treatment of malt bottles is also discussed. It was found that paraffining of the screw-caps of the bottles up to the neck helped in the prevention of infestation from outside.

29. *Trogoderma granarium* Everts, in South India.

M. C. CHERIAN and P. R. NAGARAJA RAO, Coimbatore.

This Dermestid beetle is a serious pest of wheat in North India. It was noted for the first time in the Madras Presidency in some consignments of wheat and Bengal gram imported from North India.

Under Coimbatore conditions the egg, larval and pupal periods were found to be 5-10, 125-180 and 5-37 days respectively. The longevity of the adults ranged from 4 to 17 days and the maximum number of eggs laid by a female was 40.

In the case of wheat the pest preferred softer varieties and in Bengal gram it attacked the grains already bored by Bruchids.

30. A description of a new species of *Uranotania*-diptera-culicidae from Hyderabad-Deccan.

M. QUTUBUDDIN, Hyderabad-Dn.

A new species of the genus *Uranotania* U.sp.n. has been described from Hyderabad Deccan. Diagram of the style of male genitalia is also given to show its distinction from the other Indian species.

This species differs from all the ornamented species in being devoid of ornamentation.

Yellowish white colour of the pleurae distinguish it from all the Indian species including *U. hebes*. It can be separated from *U. nivipleura* on account of the absence of a thin line of narrow scales along margin of mesonotum.

31. Biology of *Bagrada picta* Fab.

R. RAKSHPAL, Gwalior.

Bagrada picta is one of the most serious pests of the cruciferous plants. The plants of all stages are attacked by the pest. The eggs are usually laid on the leaves but in some cases they have also been observed on the stem and inflorescence. Pre-copulation period varies from two to six days. Copulation takes place very often and continues till death. It has been noted so often as on 32 days during their life of 45 days. Inter-copulation period varies from one to four days. Pre-oviposition period is from five to thirteen days, while inter-oviposition period is one to five days. Oviposition continues till the female dies. The number of eggs laid by a single female in a day varies from one to fourteen. Usually they are laid singly but sometimes in batches also. The maximum number of eggs laid by a female during its life is 104. Incubation period is two to three days during March-April. There are five moults. The life-history is completed on an average in 22 and 25 days in the case of males and females respectively. The various life-stages have been studied in detail.

32. On three exotic pests of fruit trees in the hill regions of South India.

M. C. CHERIAN, V. TIRUMALA RAO and M. S. SUBBIAH, Coimbatore.

The paper deals with three pests, viz., the fluted scale-*Icerya purchasi*, the apple-woolly aphis *Eriosoma lanigera* and the San Jose Scale *Quadraspidiotus perniciosus* in the hill regions especially in the Nilgiris and Kodaikanal. Information is also given on the natural enemies of these pests.

33. On the biology of *Aphis nerii* (Boyer de Fonscolombe).

D. MUKERJI and BASANTA KUMAR BEHURA, Calcutta.

The life-history of the common yellow aphid *Aphis nerii*, Boyer, found on *Calotropis gigantea* R.Br. in Calcutta is studied in this paper. The alate and apterous forms were most abundant during January to March 1945. No sexual forms appeared. Apterous viviparous parthenogenetic forms were reared in the laboratory in glass vials. The longevity as found under laboratory conditions during the months of February and March 1945 was 20 days. The largest number of young produced by an individual was 47 and the maximum number of broods in 24 hours was seven. The apterous forms undergo four moults. Growth of antennal joints in each phase was studied. Parthenogenesis was studied upto the fourth generations.

The aphid is attended by two species of ants—the common red tree ant *Cremastogaster dornii* Mayr. and the brownish black ant *Acantholepis frauenfeldi*, Mayr.

The authors also place on record that Thysanopterous nymphs also attack these aphids, besides the larvae and imago of *chilomenes nezmacula*, Fabr. and blind larvae of common Syrphids are its enemies.

34. Sense organs in *Goera pilosa*, Fab. (Trichoptera).

P. J. DEOBAS, Poona.

During the study of the evolution in Trichoptera, the maxillary palps of a number of species of Caddis Flies were studied on a comparative basis. It has been found that the last palpal joint in nearly all the species studied has some kind of a sense organ. The

most peculiar organ was found on the maxillary palp of *Goera pilosa*, Fab. This three jointed palp in the male is tucked upon the clypeus, and the last joint fits into a depression there. The outside surface is densely hairy. This last joint is hollow and has a rectangular wide slit on the inner side. The edges of this slit are turned inside the hollow and are studded with innumerable chitinous androconial sense organs. Each of this is embedded in a sensory cell and has 12-15 longitudinal striations on it. The living insect puts the palp forward and touches the surrounding before it makes any move. These organs are found only in the male sex, and probably function as olfactory and hydrostatic organs. The study of similar organs in other species is under progress.

35. Preliminary trials with DDT and 666 against the Indian bee *Apis indica*

M. C. CHERIAN and V. MAHADEVAN, Coimbatore.

This paper records the results of preliminary trials carried out with DDT & 666 against the Indian bee *Apis indica*. An attempt was made to find out the strength of the insecticides, which is not harmful for honey bees (1) by dusting these inside hives and (2) by feeding to bees in combination with honey, the diluent in all cases being talc. Of all the different strengths tried only 10% DDT was able to effect complete mortality of workers in 10 hours. In the case of 666 a strength of 1% killed the entire population but it took 6 days for their death. Residual effect of DDT was studied by housing colonies after different periods in a hive treated with the insecticide. Feeding trials were conducted by preparing a solution mixed with 0.05 parts of the insecticides and 4.95 parts of talc in 95 parts of honey and feeding one-fourth ounce of the above solution daily. The results showed that the action of DDT as a stomach poison was more pronounced than 666. DDT effected almost a cent percent mortality where as 666 killed only 24.1% of the population.

Fishes

36. The early development of *Eicheneis naucrates* Linn.

(Miss) C. M. JOHN, Trivandrum.

Very little is known about the breeding habits or life history of *Eicheneis naucrates* Linn. a deep water fish of tropical waters, the only information being a short description of the egg by Delsman (1931). In July 1942 three species of *E. naucrates* each measuring six inches were introduced into one of the tanks in the Trivandrum Aquarium, and by the 23rd February 1945, when they had reached a length of thirty inches spawning activities were noticed. The female which could be distinguished by her larger size, fixed herself in an almost horizontal position close to the bottom of the glass plate, and the male also occupied an almost similar position vertically above and more or less in contact with the female, but with the head slightly behind. The first spawning lasted from the 23rd February to the 4th March, during which the fish appeared agitated, breathing rapidly and completely ignoring food. On the 5th of March, the pair separated leading a normal life, but feeding voraciously. The second spawning was from the 14th to the 18th March during which the spawning position was resumed exactly as before. Description of fertilised Eggs and an account of development, structure of a newly hatched larva and of a post larval stage are given in this paper.

37. Early developmental stages of *Ophicephalus punctatus* Bl.

VALI HYDER HOSAINI and M. RAHIMULLAH, Hyderabad-Dn.

Early developmental stages have been described in the paper. Only the external characters have been observed as the facilities for noting the internal organs were not available which the authors intend carrying out later.

The observations corroborate the results of Dr. S. Raj and Prof. Mookerjee with some slight variations.

Breeding season of this fish is not confined to a definite period, it breeds throughout the year. It is not certain whether the same fish breeds twice or only once a year.

It is noteworthy that pH of waters in Hyderabad never goes down 7.8 and the water is always on the alkaline side.

Further observations are in progress.

38. On the metamorphosis of the Leptocephali of the Madras plankton.

R. VELAPPAN NAIR, Madras.

Two types of eel larvae which are common in the Madras plankton have been successfully reared into the adults. One variety belongs to the genus *Muraenesox* of the Family Congridae and the other to the genus *Muraena* of the Family Muraenidae. During the transformation of the transparent, ribbon-shaped larvae into the adult eels the most important changes taking place are: the loss of the larval set and the formation of the adult set of teeth, the acquisition of the red colour of the blood, the assumption of the adult colouration, the shifting of the anus to an anterior position consequent on the reduction of the length of the alimentary tract and the considerable decrease in the height of the body with a proportionate increase in width. In addition to these changes, the pectoral fins of the *Leptocephalus* of *Muraena* completely atrophy during metamorphosis.

39. Further observations on the ecology, bionomics and early development of the semi-terrestrial symbranchoid eel *Amphipnous cuchia* (Ham. Buch.)—the *Cuchia* eel of India.

B. K. DAS, Hyderabad-Dn.

The author has already given some account of the bionomics, habits and habitat, and development of the accessory respiratory organs in the *Cuchia* eel, *Amphipnous Cuchia* (Ham. Buch.) in the Phil. Trans. Roy. Soc., London in 1927. The present paper deals with the following further observations :—

(1) *Cuchia* is a semi-terrestrial fish and habitually spends its time in wet mud, and often makes an U-shaped or a zig zag burrow in the soft mud in which it lives, and which varies from 2.4 cm. to 6.3 cm. in diameter.

(2) The entrance and exit-holes of the *Cuchia* burrows are often mistaken for and confused with those of the fresh-water crabs, but the former are much smoother, and can only be detected by a trained eye.

(3) The burrows of *Cuchia* are often found about 2 ft. away from the edge of the water, but in rare cases they may even be seen at a distance of about 15 ft. away from the water in the soft mud round about a pond or a small stream.

(4) The eggs are laid in the wet-mud inside the burrow near one of the holes, and more often one of the parents (usually a female) keeps on guard.

(5) These eggs are either orange or amber coloured, and more or less pear-shaped (4 mm 5.9 mm. in size), and the small hatched-out embryos measure, on average, 12 mm. in length, with a very prominent yolk-sac attached towards the anterior end.

The earliest stages of the *Cuchia* embryos are white, very thin, leafy, transparent bodies, with a distinct head and eyes, and with continuous fin-folds.

(7) The post-larval forms of *Cuchia*, measuring from 40 mm. to 55 mm. in length 1.6 mm. to 2.1 mm. in breadth, have also been collected from the burrows.

(8) The ecological condition of the pond often relates to the presence of fairly thick growth of water-hyacinth within the water area and round about it in Bengal.

40. Fish eggs and larvae of the Madras plankton.

R. VELAPPAN NAIR, Madras.

For the study of the developmental stages of the common fishes of the Madras Coast, regular plankton collections were made from the Sea and the brackish waters of the Cooum and Adyar, particularly when these rivers were in communication with the Sea during the rainy season which seems to be the breeding period for most of the fishes of this Coast. Six types of pelagic fish eggs have been obtained from these collections. Three of these types have clear segmented yolk which indicates their position in the Family Clupeidae and two of them have been definitely determined as belonging to the genus *Stolephorus*. Of the remaining three types, two have numerous oil globules and they can be referred to the genus *Solea* of the Family Soleidae. Lastly, a type of spherical egg with the yolk prominently segmented along the periphery and with a single large oil globule has been identified as belonging to the Family Carangidae and probably to the genus *Caranx*. The collections also contained the post larval stages of *Elops indicus*, *Stolephorus* sp., *Mugil* sp., *Trichiurus haumela*, *Ambassis miops*, *Therapon jarbua*, *Lactarius lactarius*, *Leiognathus ruconius*, *Gerres lucidus* and *Scatophagus argus* and the paper gives a general account of the different forms with special reference to pigmentation which is an important diagnostic feature of the larvae of fishes, together with their periods of occurrence along the Madras Coast.

41. A note on carp spawning in the Godavari and Kistna (Madras).

P. I. CHACKO, Madras.

In the Godavari and Kistna rivers, the major carps, the Catla (*Catla catla*), the Kalbasu (*Labeo calbasu*), the Fringe-lipped Carp (*L. fimbriatus*) and the White Carp (*Cirrhina cirrhosa*), breed from July to September, when the rivers are in floods, and are characterised by rapid flow of water and muddy discolouration. The Carps move into the upper reaches of the rivers in small groups in search of favourable breeding grounds, which are river-sections characterised by large submerged rocks or emergent vegetation. The temperature of the water in these areas range from 22 to 26°C. Maximum spawning takes place on cloudy days with intermittent drizzling. The freshly fertilised egg measures 1.0 to 1.28 mm. in diameter; and after a few minutes it develops a perivitelline space 3 mm. in width. The eggs float at the top layer of water as a glistening sparse mass of about eight cubic feet in area, with the eggs one to two inches apart, and drifting down the river at a distance of six to eight feet from the margin, at a velocity of about 5 to 7 miles per hour. Hatching takes place within 16 hours. The newly hatched-out larva measures 4.5 mm. in length, with an elongated yolk-mass of 3.6 mm. The eggs of Catla are lighter than those of the Fringe-lipped Carp; and therefore get quickly drifted into the irrigation canals and paddy-flats. This accounts for the predominance (80%) of Catla fry in the canals and paddy-flats, and for the predominance (80%) of fry of the Fringe-lipped Carp in the rivers. The collection of spawn for stocking of tanks, as is done in Bengal, is not practised in Madras.

42. Bionomics and life history of *Etroplus suratensis* (Bloch) with special reference to stocking tanks.

V. K. BHASKARAN, Trivandrum.

A detailed survey of the backwaters and coastal regions of Travancore has shown that the normal habitat of *Etroplus suratensis* is the marshy regions of the back waters in the vicinity of the bar mouth and within strong tidal influence. Their food consists mainly of decaying organic remains found in the bottom mud and also of algae and moss. In the fresh water areas they feed on the rhizomes of Blyxia and the flowers and fruits of *Aponogeton crispus*. Though the young ones are exclusively herbivorous in habit the older ones are found to feed on fish larvae and aquatic worms. It has been found that salinity plays a very important part in the healthy growth of the fish and in determining their breeding habits. In places which are under tidal influence and where the salinity is comparatively high the fish breeds almost throughout the year while in fresh water the breeding is confined to the dry seasons and coincides with the encroachment of saline water further inland. Under normal conditions the fish lays five thousand to six thousand eggs at a time and these eggs are attached one by one to the flat surface of submerged stumps or posts planted in the bed of the lakes. For purposes of artificial culture it has been found that the fish could be induced to attach their eggs to the broad bases of coconut petioles planted under water. After eggs are attached to these, they may be transferred through water to culture ponds and replanted. By this method young ones of *Etroplus* can be reared in large numbers, for stocking purposes.

43. On the life history of *Ophicephalus striatus* Bloch.

RAMANATH BHATTACHARYA, CALOUTTA.

Habitat—Shallow edges of the ponds, ditches, rivers or *bheris* filled with weeds or long grasses. Never hesitates to live in polluted water.

Distribution—Wide and found abundantly in India, Burma and Ceylon.

Spawning habit—The fish is monogamous and in the breeding season selects nests which differs from that of other nest-building fishes like Gourami in the sense that it is never constructed by the fish for habitation and is a temporary one only selected for the purpose of breeding. The selection of the nest amidst the water weeds begins as soon as the water in the early spring gradually begins to decrease. The nature of the nest is a small grassless or weedless or reedless area amidst the dense weedy place; it may be in the edges or inside the watery area, but the condition is that the place must be a shallow one. The bottom of the nest is perfectly smooth and does not contain any vegetation.

Economic importance—Edible fish and is favoured by many specially the poorer class of people. The fish is extremely carnivorous and voracious. Presence of the fish in the pond where carp culture is practised is dangerous and disastrous.

Breeding season—Middle of May to the end of August.

Nature of Egg—Floating, non-adhesive, round and amber in colour. Size after swelling is 1.25 to 1.5 mm.; floats in batches within the nest. Contains oil globules,

Spawning—After usual rubbing and coiling the ova and sperms are set free. The spawning if disturbed may continue for one or two days and the eggs are set free in batches; spawning at intervals is of common occurrence even when undisturbed. The adult especially the female nurses the offspring and protects them.

Segmentation—Regular, the limit of time from the starting of segmentation to the completion of many celled stage is generally within 2 to 3 hours.

Completion of yolk invasion—6 hours since fertilisation.

Formation of embryo—7 hrs. 45 minutes since fertilisation.

Appearance of heart rudiment—15 to 18 hours since fertilisation.

Beginning of pulsation—17 hours since fertilisation.

Pulsation record—120 per minute just at the beginning. 150 per minute after an hour.

Appearance of median fin-fold—12 hours since fertilisation.

Appearance of pectoral fin—20 hours since fertilisation.

Time of hatching—24 hours after fertilisation in nature and 48 hours in the aquarium.

Hatching period depends on the intensity of sun's ray like *Ophicephalus punctatus*.

Appearance of pelvic fin rudiment—7th day since hatching.

Appearance of scales—13 days since hatching.

Colour of newly hatched larva—Pigment cells begin to develop pigments of black colouration. Pigment begin to appear in the eyes.

Size of larva—After hatching 2.8 mm. One day after hatching 4.9 mm. Two days after hatching 6 mm. Seven days after hatching 6.2 mm.

Appearance of colour in the body—After a month about on 15 mm. stage the characteristic colouration of the young begins. There appears a band of reddish-orange colour starting from behind the eye and ending at the base of the caudal fin with a knob and covering the entire breadth of the myotome. This colour is retained for about 3 months after hatching.

The matured adults are usually two years old and over a foot in length.

The lowest temperature the young can tolerate—The minimum temperature that the young can tolerate is 11° C.

The nature of food taken—Just after the opening of the mouth the larva likes unicellular algae, multicellular algae and protozoa respectively. The post larval and early fry stage are fond of cladocera and other small crustaceans like daphnia and cyclops. The fry afterwards restrict its diet on purely animal food like shrimps, prawns, aquatic insects, young fish, tadpole etc. Toad, frog, small snake etc. are not uncommon in the menu of the adult fish. Role of vegetable is very insignificant.

44. Observations on the breeding habits of *Ophicephalus striatus* Bl.

M. RAHIMULLAH, Hyderabad-Dn.

Although early stages of this fish have been worked out by many people still there is very little information regarding its other habits. Some experiments were carried out by the author and field observations made.

The breeding of this fish is not confined to a specified period but is throughout the year.

Young fry in each batch number from 2,000 to 2,500 and are of bright golden yellow colour. They change over to natural colours within a month and then scatter all over.

The rate of growth is quite rapid and it has been observed that *Ophicephalus striatus* attains a size of 3 ft., *O. marulius* 3½ ft. which is attributed to the moderate climate of Hyderabad.

45. Acclimatisation of an exotic fish, *Etroplus suratensis* (Bloch) in the Hyderabad State.

M. RAHIMULLAH, Hyderabad-Dn.

500 young ones of *Etroplus suratensis* were imported from Madras. Only a few reached alive owing to the change from brackish to fresh water. Two pairs bred during the rainy season of 1943 and are breeding every year. Some were left in a small pond and their breeding also continues. It is proposed to utilise the A. R. P. Static tanks and other 'pucca' reservoirs which are present in very large numbers in the Hyderabad city and Aurangabad. Stocking of wells of the Maharawatadi districts is also contemplated with this fish.

46. On the migration of inland water fishes of Madras.

P. I. CHACKO, Madras.

The major rivers in the Madras Presidency are in floods from June to December. The movements of the migratory fishes occur during this season. The chief fishes entering the rivers (anadromous), to a distance of 60 to 210 miles from the sea, are the Hilsa,

Hilsa ilisha, the Becti, *Lates calcarifer*, the Jew-fish, *Sciaena belangeri*, the Mullet, *Mugil olivaceus*, the Tarpon, *Megalops cyprinoides* and the Indian Salmon, *Polynemus tetradactylus*. The Hilsa ascends the rivers for spawning, whereas the others do so for feeding. Large numbers of berried individuals of the marine prawn, *Penaeus indicus*, shoal into the rivers to a distance of 100 miles from the sea, for both breeding and feeding purposes. Over 20 species of marine fishes of commercial importance enter the deltaic areas of the rivers, where the tidal influence reaches a distance of about 35 miles from the river mouths, for spawning, feeding and temporary shelter. The freshwater eel, *Anguilla bengalensis*, is the only catadromous fish in the province; but it is poorly represented. The Goonah, *Bagarius yarrelli*, the Carnatic Carp, *Barbus carnaticus*, the Mahseer, *B. tor*, and the Brown Mahseer, *B. hexagonolepis*, are the chief species which move up and down the upper reaches of the rivers for breeding and feeding purposes. The major Siluroids and Carps show local migrations in the sections of the rivers flowing through the plains. The causes of migration, and the seasonal regularity of migration are discussed. Measures for preventing indiscriminate capture are suggested.

47. A study of the effects of factory effluents on the Bhadra river fisheries at Bhadravati.

B. S. BHIMACHAR and AUGUSTINE DAVID, Bangalore.

A brief account of the nature and the volume of effluents discharged into the Bhadra river from the Mysore Paper Mills and the Mysore Iron Works at Bhadravati is given. Observations made on a detailed biological survey of the river for a distance of about twenty miles are recorded. Chemical analysis of water collected at different regions of the river, both above and below the source of pollution, has been tabulated. The depletion of the normal aquatic fauna and flora including fishes near the source of pollution and their gradual reappearance lower down the river, the factors affecting the migration and breeding of fishes and the abundant occurrence in the highly polluted area of organisms suited to overcome the effects of pollution are discussed. Records of physiological experiments conducted on some fishes in the polluted part of the river are given.

48. Fishes of Mysore State.

B. S. BHIMACHAR and AUGUSTINE DAVID, BANGALORE.

A list of about 140 species of fishes collected from different parts of the State is given. Brief notes are added on a few forms of systematic and zoogeographical importance. The abundant differentiation in the fish fauna of the two neighbouring drainages in the state—the Tungabhadra and the Cauvery and the probable causes responsible for it are discussed.

49. A record of the distribution of Freshwater fishes in some districts of the Karnatak and Portuguese India.

P. W. GIDEON, Dharwar.

During the past few years a collection of fishes was made from the tanks, nullahs and rivers of Dharwar and surrounding Districts. Forty-three species of fish belonging to 27 genera were recorded in 22 localities.

The largest number of species found in one locality was 13, and the species which showed the largest distribution was *Rasbora daniconius* which was found in 11 localities.

50. Preliminary observations on the food of post-larval fishes.

K. GOPINATH, Trivandrum.

Along the Trivandrum coast, larval and post-larval stages of fishes begin to appear from November onwards and continue to be present till March or even April, and this period coincides with the period of maximum intensity of zooplankton in this area. Post-larval stages of *Engraulis mystax* (Bl. Shn.), *Leiognathus blochii* (C.&V.), *Upeneoides vittatus* (Forsk.), *Gobius* sp. and *Saurus* sp. were examined and their stomach contents in all cases, except that of *Gobius* were found to comprise totally of zooplankton organisms. Copepod, Leucifer, Mysis, Decapod remains, Amphipod and Molluscan young ones were the chief items, copepods being by far the commonest and major constituent. Acartia, Remora, Corecaeus and Miracia were the main forms of copepods represented in the stomach contents and evidently they show a selective action in feeding. In *Gobius* there were large number of diatoms and Amphipods, and this was traced to their peculiar habitat, near the bar mouth adjoining the Veli Lake.

The feeding habits of these post-larval forms foreshadow the feeding habits of their adult forms, and in the five species under investigation, neither any alternative diet nor any correlation between the size of the food organism and the size of post-larva was noticed.

51. On the composition of food and their correlation with weight and length of the body in the development of *Ophicephalus punctatus* Bloch.

H. K. MOOKERJEE, D. N. GANGULY and M. ISLAM, Calcutta.

Very little is known about the food of common Indian fishes of economic importance. 150 specimens of the fish varying from 3.5 mm. to 240 mm. were collected from the same locality, the stomach contents of them were carefully removed for the estimation of the quantities of various items of food. After examination the gut contents were stored in 5% Formaldehyde for future reference.

Observations were made at the time of capture and preservation regarding the regurgitation of food by the fish but we could not find such regurgitation.

Our observation leads to the following :—

1. Up to 4 mm. stage the fry absorb the yolk only.
2. Between 4 and 5.5 mm. stage they take unicellular and multicellular algae in the proportion of 94 : 6.
3. Stages beyond 5.5 mm. show a tendency towards carnivorous diet.
4. The percentage of animal food increases onwards and when that reaches 1/3 of the total quantity, a marked increase in the body weight takes place. Thus we observe in 5.5 mm. stage the weight is 0.81 mg. and it increases to 3 mg. in 6.5 mm. stage where the composition of the food is—
Algae 70.9 % (unicellular 50.9% and multicellular 20%).
Animal 29.1% (protozoan 28.8% and crustacea 0.3%).
5. From 15 mm. stage the proportion of the plant food in the menu gradually decreases and the fish show a more liking towards protozoa, rotifers, insects and copepod crustaceans. With the increase of crustacean diet the rate of growth in bulk increases and a sudden increase in the weight in proportion to the length of the body has been marked.

6. Now onwards the fry continue the same diet. The preference being shown towards protozoan and crustacean diet. The insects form a minor proportion; the maximum that has been observed is 27.7%; generally it varies from 1.7% to 15%. The main bulk of the insect diet comprises may-fly larvae, dragon-fly larvae and chironomid larvae; mosquito larva is seldom seen. Thus it is obvious that whenever any animal with softer body is available the fish refuses to take insects with bristles and spines.

The increased proportion of copepods mainly cyclops found in the stomach of the fish is the definite proof of the utility of this fish in the control of guinea-worm rather than mosquito control.

7. From 80 mm. stage the fish generally refuse to take the slightest quantity of vegetable matter although in isolated cases fish with stomach full of vegetable food has been found. A thorough search into the stomach of many fishes of the corresponding size has made us confident that when animal foods are available the role of vegetable as food in the adult is insignificant.

8. From a stage of about 140 mm. the fish show an inclination towards fish diet which reaches maximum in adults where the percentage of fish in the whole diet varies between 50 to 100%. Thus the presence of this fish in the pond where the fish rearing is practised should be avoided in order to prevent the utter destruction in the fish population.

52. Correlation between food, body weight and length of the gut in *Cirrhitina reba*.

H. K. MOOKERJEE and S. N. SEN GUPTA, Calcutta.

The question of food of fry and fishes is essential from ecological and growth standpoint. Our knowledge in this respect is very scanty.

To determine the nature of food of *Cirrhitina reba*, about 100 specimens varying from 10 mm. to 90 mm. were collected. The fish were cut open, the stomach-contents were carefully removed and examined for the estimation of the quantities of various items of food.

Our observations are as follows :—

1. Since the yolk absorption upto the 20 mm. stage they take minute unicellular algae followed by protozoa of various nature. The length of the alimentary canal is now more or less equal to the length of the body.
2. Stage between 20 mm.—50 mm.

The proportion of the animal food gradually decreases. They show a greater tendency towards vegetable than the animal diet in the ratio of 2 : 1. So they may be called herbivorous. With the change of diet the alimentary canal also increases.

3. Stage between 50 mm.—80 mm.

Now onwards the fry continue the herbivorous diet of algae and other phanerogamic plants in semi-rotton condition as well. Proportionately the animal food decreases considerably. The length of the alimentary canal increases in the proportion of 4 : 1.

4. Stage from 80 mm. and onwards.

Fingerling shows greater preference for semi-rotton higher plants to that of the previous stage, the algae being scanty. The percentage of Crustacea continues as same. Further increase in the length of the alimentary canal in proportion to the body-length was observed in the ratio of 5 : 1.

53. On the composition of food of the Indian mullet *Mugil parsia* (Ham.) with suggestion to culture them in fresh water ponds of Bengal.

H. K. MOOKERJEE, D. N. GANGULY and AJIT SIRCAR, Calcutta.

The present investigation has been undertaken by us because of very little work has been done on the composition of the food of Indian edible fishes especially that of the Estuarine fishes. More than 100 specimens of different stages between 18 to 115 mm. were collected from the estuarine area of Matla river and their stomach contents were studied.

It is observed that :—

- (i) Upto 18 mm. stage the fry takes large percentage of unicellular and multicellular algae, with crustacea forming 1/5 of the total bulk. A considerable amount of mud and sand are also found.
- (ii) From 19 mm. to 22 mm. stages the percentage of algae, mud and sand suddenly falls and rapid increase in the percentage of crustacea in the diet takes place.
- (iii) Beyond 23 mm. stage the fish favours unicellular algae especially diatoms very much with a little quantity of multicellular algae, rotten parts of higher plants, volvox and infusoria; crustacea is seldom seen. The percentage of sand and mud also increases.
- (iv) The main constituent of the diet of different developmental stages are different types of diatoms (main bulk of the diet) Oscillatoria, Pleurococcus, Volvox, Infusoria, and among crustacea shrimp and calanus.

From the nature of food, it is obvious that the fish are generally bottom feeders but for a transitional period that is between 19 to 22 mm. stages they roam at the surface, so they take a large amount of surface planktons like crustacea and unicellur algae like Pleurococcus. Presence of very little amount of mud and sand in the gut in this stage also corroborate this statement. Culture of this fish in fresh water ponds is very easy when the proper food is known. We have had the experience of rearing this fish in fresh water. Abundance of the fry of this fish is obtainable from the estuarine areas like Port Canning, Diamond Harbour, Kolaghat and like places during the months between May and Aug. If fish farmers, especially the pond culturists of Bengal, pay their attention towards the cultivation of this delicious fish, they would surely be profited and would meet the fish scarcity to some extent.

54. Histology of the alimentary tract of a fresh-water Goby, *Glossogobius giuris* (Hām.).

SYED MOHD MOHSIN, Hyderabad-Dn.

Histological structure of the various parts of the Alimentary tract is described in this paper. The main features are :

- (1) Tongue has a large number of mucous cells. Taste-buds are not prominent.
- (2) Buccal Cavity : Epithelium has a corrugated appearance. Goblet cells are present. The connective tissue forms a sort of loose meshwork. In the floor of the mouth mucous cells are aggregated and give the appearance of a sort of gland.
- (3) Oesophagus : Mucosa is much branched and mucous cells are numerous. Blood-vessels are not profuse in the submucosa, but plenty in the serosa. Longitudinal muscle fibres are found in the form of scattered bundles; circular layer of muscles is quite thick.
- (4) Stomach : Gastric muscocal folds are highly branched. Gastric glands are very well-developed; their cells are at places cubical and in some regions rectangular. Blood-vessels and nerve fibres very distinct.
- (5) Pylorus : Longitudinal muscle-fibres very thick and circular layer thin. Mucosal folds are elongated and branched. No distinct sphincter present.

- (6) Intestine : Mucosa has a folded appearance. Goblet cells very numerous. Blood-vessels are profuse. Serosa is very thin.
- (7) Rectum : More or less resembles the intestine, excepting that the mucosal folds are more branched and they contain many mucous cells. The layers of muscles are not uniform.

55. Determination of age by scale-reading in Indian Fresh-water fishes.

H. K. MOOKERJEE and S. N. SEN GUPTA, Calcutta.

Determination of age of a fish has practical utility for laboratory and field. Europe having wide variation of temperature the growth of a fish varies accordingly. Hoffbaur (1898), Einar Lea (1911), Wallace (1907, 09, 11), Winge (1915), Taylor (1916) and others have recorded the scale-reading for determination of age with European fishes.

In India and specially in Bengal where the variation of temperature is limited it is questionable whether such reading would be possible.

The European workers have used all sorts of treatment of scales with chemicals such as caustic soda followed by staining.

We are running a scheme on the life-history, bionomics and development of fresh-water fishes of Bengal financed by the Imperial Council of Agricultural Research for a number of years and we have found that without chemical treatment it is possible to read the scale of teleostean fishes.

Scales to be taken out from close to the lateral line, cleaned in water and should be put in between the two slides and the two ends to be tied up with the strings to hold it in a flattened condition. After keeping it in air for sometime for drying, it should be read with the aid of a hand lens and not under the microscope, the latter puzzles more to count the number of different forms of rings. In summer the growth is much more, so the rings are wide apart and in the winter when the growth is retarded due to the disability of taking adequate quantity of food the rings are in close apposition. Now by counting the bundle of apposed rings one can determine the age. The number of years will be the number of winter rings plus one, to represent the initial year to start with. This is so very handy that any lay man can read the scale without any difficulty.

Amphibia

56. A note on the mechanism of eyelid closure in *Rana hexadactyla*.

A. ANANTHANARAYANA AYER, Madras.

The lower eyelid of *Rana hexadactyla* gives out at its anterior and posterior angles small tendons which run downwards and medially and gradually become thinner and then unite to form a loop encircling the eyeball and passing below it. The medial and lower part of the loop lies in the inferior portion of the retractor bulbi muscle and some fibres of this muscle are attached to the convexity of the loop. When the eyeball is retracted by the retractor bulbi, the tendinous loop is actively pulled on by muscle fibres attached to it and the eyelid rises up in a coordinated movement. The mechanism seen here differs from that described by Holmes (1938) in *Rana esculenta* where the muscular attachment of the loop is absent and the retraction of the loop leading to the elevation of the lower eyelid is a passive action caused by the migration of the eyeball. The condition in *Rana hexadactyla* also differs from that described by Stibbe (1928) in the British Frog (species not named) where the tendon from the medial angle of the eyelid and the loop formation are both absent.

Reptilia

57. The histogenesis and development of the corpus luteum in *Cerberus rhynceps*.

(Miss) MARY SAMEUL, Madras.

The paper gives an account of the histology, development and regression of the Corpus luteum in a viviparous brackish-water snake, *Cerberus rhynceps*. The development of the corpus luteum in this form is found to resemble in its essential respects that of the viviparous sea snakes *Enhydrina schistosa* and *Hydrophis cynnocinctus* as described by the author, the luteal cells being the much hypertrophied epithelial cells of the unruptured Graffian follicle. The mode of vascularisation and the behaviour of the connective tissue theca, however, vary in this species from that of the sea snakes.

Only superficial ingrowths of fibro-blastic cells from the theca interna into the luteal tissue take place with the result that there is no invasion of the luteal cells by the blood vessels. The corpus luteum has a long intra-ovarian existence, degeneration of luteal tissue beginning when the embryo measures 10 cm., and continuing until the time of the birth of the young when the embryos are about 19 cm. The origin of the luteal cells, the fate of the theca interna cells and the probable function of the corpus luteum in reptiles are discussed.

58. Some stages in the development of the Pineal body of *Calotes versicolor* Daud.

K. K. TIWARI, Nagpur.

Some stages in the development of the pineal body in *Calotes versicolor* Daud are described. The earliest stage shows the origin of the pineal eye as a constriction from the anterior end of the pineal sac which arises from the roof of the fore brain, very much like its origin in *Sphenodon* (Dendy, 1910).

More advanced stages show the pineal eye, the pineal sac and the dorsal sac. In earlier stages the pineal eye is more or less oval in shape but later it gets flattened and the vitreous chamber is reduced.

The paraphysis and pineal nerves appear to be absent. When compared with the pineal complex of *Sphenodon* (Dendy, 1910) the condition in *Calotes* shows marked degeneration. The retinal cells of the pineal eye show a very different arrangement from that described in *Sphenodon*.

Mammalia

59. Hair tracts in *Pteropus giganteus giganteus*.

K. I. VERGHESE, Madras.

The hair tracts of *Pteropus giganteus giganteus* are figured and described.

The direction of hair on the dorsal side from crown to rump is cranio-caudad with tendency for mid dorsal divergence in the lower region; on dorsum of brachium, proximodistal and on dorsum of antebrachium, towards the elbow; on the dorsum of posterior limb it is postaxial. Ventral side of body shows point of divergence at junction of neck and trunk and lower down slight divergence away from middle line; ventral sides of limbs show a divergence extending to patagium.

The hair tracts of this volant animal, which at rest hangs inverted from trees, resemble those of *Semnopithecus*, a Primate of quadrupedal plantigrade mode of locomotion. This similarity could be explained by assuming the influence of two factors determining hair tracts in mammals, one a primitive primary hair tract pattern retaining the direction of the scales of the ancestors of mammals, and the other a superimposed secondary hair tract pattern dependent on toilet, falling rain etc. It is suggested that the hair tract of *Pteropus* might be the primary tract and hence bears a resemblance to that of other mammals which also retain unmodified the primary tract pattern.

60. Preliminary observations on the development of the external form in the palm squirrel (*Funambulus Palmorum* Linn.

D. H. VEERAAIAH, Bangalore.

A preliminary study of thirteen stages of embryos measuring from 0.5 mm. to 4.5 cm. has been made with a view to trace the development of the external form. The Crown-rump length and weight as adopted by Prof. Mall for human embryos, has been adopted to determine the age of the series. The head is at first laterally flattened with a prominent "Cephalic bump", gradually becomes rounded as age advances. Development of the nose, ear and mouth has also been followed. The eyelids make their appearance in the form of incomplete folds gradually fuse and cover the eyes. The appearance and development of the hair follicles, vibrissae and hair tracts are traced. Differentiation of sex is followed in the series of embryos.

SECTION OF ANTHROPOLOGY AND ARCHAEOLOGY

PRESIDENT : R. E. M. WHEELER, M.C., D. Litt., F.B.A., F.S.A.

1. Prehistory of the Deccan.

M. H. KRISHNA, Mysore.

The excavations at Brahmagiri consisted of a detailed overground survey and a number of trial excavations. The site is about half a mile to the north-west of the village of Roppa which is directly to the east of the Brahmagiri hill in the northernmost part of the Mysore State, projecting into the Bellary District. The results were obtained first in excavation 10 confirmed by excavation 11 and established by excavation 16. The loss was about 40 to 30 feet at the surface and went down to 18 feet below the ground level where hard gravel was met. The excavations reveal about 9 distinct levels, the first few of which are historic, viz. (1) Chalukya, (2) Satavahana and Maurya. But the finds below the Maurya are (3) Prehistoric Iron Age, (4) Copper Age, (5) and (6) Neolithic age, (7), (8) and (9) Microlithic Age. Since there was a definite development of culture, it is suggested that the earliest finds of the place take us back to about 5000 or 6000 B.C. The Copper Age corresponds to 2500 B.C. well-known at Mohenjodaro. The Maurya period which is more than 2000 years old appears at 2½ feet below the surface.

2. Identification of Muziris of the Greek geographers with Kodunkolur or Cranganore of Cochin State.

P. ANUJAN ACHAN, Trichur.

The location of Muziris of the Greek Geographers was fixed by scholars like Burnell, Caldwell and Yule at 'Muyiri-kod or Musiri, which, as Kodunkolur or Cranganore (10° 14' N., 76° 11' E.), was an important port in mediaeval times'. Their argument was based on the 7000 stadia named in the Periplus as the distance between Barygaza and Damirica (Dravida-desa). From Barigaza or Broach on the mouth of the Narmada "the whole course to the end of Damirica is seven thousand stadia; but the distance is greater to the Coast Country". 7000 stadia is approximately 700 English miles.

2. After naming the several market-towns beyond Barygaza, the Periplus continues, "Then come Naura and Tyndis, the first markets of Damirica, and then Muziris and Nelcynda, which are now of leading importance. Tyndis is of the Kingdom of Cerobothras; it is a village in plain site by the sea". Wilfred Schoff has identified Tyndis with the modern Ponnani (10° 43' N., 75° 56' E.), 'as the distance of 500 stadia between Tyndis and Muziris, indicated this more than any other place'.

3. "Muziris, of the same Kingdom", says the Periplus, "abounds in ships sent there with cargoes from Arabia, and by the Greeks; it is located on a river, distant from Tyndis by river and sea about five hundred stadia, and up the river from the shore twenty stadia. Nelcynda is distant from Muziris by river and sea about five hundred stadia, and is of another Kingdom, the Pandian".

4. The limits, therefore of the kingdoms of Cerobothra and of the Pandian, according to the Periplus, get marked within the 500 stadia, or 50 miles, between Muziris and Nelcynda. Moreover, the text tells us that Muziris was distant from Tyndis, "by river and sea, 500 stadia", and Nelcynda from Muziris "by river and sea, 500 stadia". Schoff says that 'this can hardly refer to anything but the Cochin backwaters'.

5. Pliny, who wrote between 73 A.D. and 77 A.D. describes Muziris as "the first emporium of India", where "reigned Cacla-bothras". He mentions another port "Neacyndon" where, he says, "reigned Pandion".

6. In Ptolemy's "Treatise on Geography" (135—150 A.D.) Muziris is described as an "Emporium" along the coast of "Dimirica", and in his map of Asia, "Muz'ris Emporium" is marked at 14° latitude and 117° longitude, on the mouth of a river named "Pseudostomos". Some distance further south is also marked the town "Melkinda". Though Ptolemy's system of graduation may be faulty, the names of some of the places around Muziris marked in his map are almost identical with their present equivalents; for instance, Padapperura-Paudopatana of Indikopleutes is the same as *Karupadana*; Paloura is the same as *Paloyur*; and the coastal town Cereura is perhaps the present *Paravur* opposite to Cranganore.

7. The above evidences unhesitatingly indicate that the Muziris of the Greek Geographers is to be located somewhere about the present Kodunkolur or Cranganore.

8. With a view to finding out if there exists any archaeological evidence for this contention, the Government of Cochin have just commenced certain trial excavations at Cranganore on scientific lines. The result of the undertaking may be awaited with interest.

3. Were the Rigvedic Indians proto-Nordics?

N. M. CHAUDHURI, Calcutta.

In the present paper is discussed the theory advanced by some anthropologists that the Rigvedic or Vedic Aryans were Proto-Nordics. The theory is divided into two parts: determination of the characteristics of the Proto-Nordics and determination of the type of the Vedic Aryans. The characteristics of the Proto-Nordic type are held to be dolichocephaly, leptorrhiny and blondism. Proto-Nordic affinities have been claimed for the modern Kurds and extinct races like the Kassities, Medes, Kimmerians, Mandas, Scythians etc. whose physical types are not much known. The third characteristic viz. blondism is modified into partial blondism by those who claim Proto-Nordic affinities for the tribes of the Hindukush and south of the Hindukush. The human remains found at the Dharmarajika monastery at Taxila, destroyed by the White Huns in the 5th century, showing a dolicho. leptor. type is taken to be the type of the Vedic Aryans. Partial blondism is assumed for this type on the analogy of the Hindukush Kafir tribes who show the presence of a tall, dolicho. leptor. partly blond strain among them. The Dharmarajika type identified with the Hindukush (Kafir) type and described as Proto-Nordic is held to represent the Vedic Aryan type. This means that the Vedic Aryans were a tall, dolicho., leptor., partly blond homogenous race who came from the Eurasiatic steppelands.

It should be noted that N.W. India was invaded by foreign hordes belonging to different ethnic stocks, many of whom settled down there, from the 5th century B.C. after Christ, e.g. the Persians, Greeks, Sakas, Parthians, Yuechis etc. Early literature mentions Yavanas, Sakas, Pahlavas, Chinas, Daradas, Paradas, Hunas, Hara-Hunas, Parasikas, Tukharas etc. The Huna invasions were probably preceded or accompanied by Jat, Gujar, Abhira infiltration. The Dharmarajika remains found at a frontier post like Taxila probably represent a very mixed type. In the next place, analysis of anthropometric data of the Hindukush tribes show a predominant tendency to brachycephaly affiliated to the Irano-Pamirian type. A belt of brachycephalic tribes, indigenous to the region, hold the approaches from the Eurasiatic steppelands to India. Lastly, examination of the internal evidence of the Rigveda shows that the Rigvedic Aryans were of different physical types, skin pigmentation prevailing among clans and yajamana tribes, and there were therefore no real Iranians.

4. Identification of the unicorn in the seals of Mohenjo-Daro and its relation to the religion of the Indus Valley Civilization.

C. R. ROY, Karachi.

Large numbers of seals with "Unicorn" have been found in the excavation at Mohenjo-Daro. Unicorn was connected with some religious cult. According to Sir John Marshall the religion was connected with the cult of Shiva and Mother Goddess, but that was not wholly correct. The Cult of the Unicorn was the principal religion. Unicorn has been

identified as the wild ass the physical characters of which agree in details with that of the Unicorn except the "fictitious" single horn which has been put by the artist to show the aspect of "Divinity". Wild ass was the native of the Indus Valley. Horse was absent. The wild ass was regarded with awe and reverence which gave rise to the worship of the Zoomorphic God. Later, it was considered to be the Vehicle of the Assini so named after the name of the animal Assa or Aswa. After the importation of horse both the animals were called by the name of the Ass and both were regarded as divine Aswas. The two Unicorns in the Pipal tree in the seal are the two divine Aswas in the Aswatha tree which derived its name from the animal Aswa. These two divine Aswas gave rise to the cult of Twin Gods Asvins in the Vedic times. The peculiar object before the Unicorn has been identified as a hay-rack and water trough, used as a bait to catch the animal and afterward as a cult object, and in Vedic times it became Yupa of the Assini. The principal religion of the Indus Valley was the cult of Assini which was probably conceived as the wife of Sun God.

5. Folk songs of Gujarat.

SREEMATI MANGLABEN DANI, Nadiad.

Educated Gujarat has developed an appreciation of the literary beauty of the simple songs sung by the rustic folk of the country. Already there is a well edited collection of such songs published in Gujarati by Messers Zaverchand and Gokuladas.

The present paper is a collection of eight Gujarati folk songs hitherto unpublished, freely rendered in English. Some of these songs were collected by a direct approach and association with those who are in the habit of singing them with rapture. Even a cursory reading of the translation would enable the reader to have a peep into the beauties of eastern culture in a suggestive manner. The poems suggest more than they express. There has to be a reading between the lines which can only be done by one who is familiar with the background of the scene.

A girl, recently married, describing the members belonging to the family of her husband, a woman's burning desire to be a mother of a child that would be naughty enough to keep her busy, a warm welcome to the newly born child, the light of the house, a request of a beloved wife to her husband not to leave home for service, selfless love between the brother and the sister, woe fallen on the family by the death of a newly married young man, and the sadness and fury of a Rajput warrior to find on returning home that his sweetheart is removed by a wicked piece of witchcraft — these briefly are the topics of these songs.

6. Notes on a test survey of famine condition in Bengal Villages from November 1943 to March 1944.

T. C. Das, Calcutta.

The author of this paper organised a sample survey of the destitutes who thronged the streets of Calcutta in September 1943 with the help of his colleagues and pupils of the Department of Anthropology, Calcutta University. This was followed by a test survey of famine condition in the districts of Bengal which were most seriously affected. This part of the work was completed between November 1943 and March 1944. This test survey in the rural parts forms the subject-matter of the present paper. It deals with the data collected from 1019 families living in nine districts of Bengal. The author here describes (a) the nature of the population surveyed, (b) their occupations, (c) their earning capacity and dependence, (d) the assets sold by these families during the famine, (e) their indebtedness, (f) the reduction of economic status of the families surveyed and (g) the number of deaths in these families within six months from date of investigation.

7. Rehabilitation work among the criminal tribes.

A. M. SOMASUNDARAM, Masulipatam.

The problem of the Criminal Tribes has not received proper attention either from scientists or from administrators. They are brought under the operation of the Criminal Tribes Act, which is causing them manifold difficulties and handicaps. These arise from two factors; 1. The anti-social attitude of the higher caste Hindus who deny to them the cultural and economic amenities; and 2. The policy of the Government which has treated the subject as a branch of Police Administration. A brief survey of the theory

of Lombroso which seems to have some connection with the C. T. Act. The Criminal Tribes, in the light of recent blood group and paternity tests, represent a heterogeneous lot, and show a higher incidence of 'B' group blood.

Crime is not hereditary. It is unjust to treat a huge mass of humanity as criminals. They are suffering from economic helplessness and the apathetic attitude of the higher caste people while their handicaps are manifold. Reclamation of these tribes is to be taken up in any scheme of reconstruction connected with social work. The Criminal Tribes should be transformed into peaceful and useful units of modern society. Great schemes of reform are to be envisaged. Social Workers and Institutions should strive for the removal of the social stigma from which these Tribes are suffering. C. T. Act is to be repealed. Administrators should change their policy towards them. Methods of Reform are to be introduced. Scientific researches should be encouraged by the Administrators.

8. Biometric analysis of anthropological measurements on castes and tribes of the United Provinces.

P. C. MAHALANOBIS, D. N. MAJUMDAR and C. R. RAO, Calcutta.

This paper discusses the results of a biometric analysis of measurements of 13 characters on about 2900 individuals belonging to 23 castes and tribes of the United Provinces taken by D. N. Majumdar during the 1941 census.

For discrimination, classification and graphical representation, canonical variates (which are suitable linear combinations of the measured characters) were constructed and suitable intra- and inter-group studies were made. With the use of Mahalanobis' 'generalised distance' these 23 castes and tribes were then classified into 4 broad groups. Resemblance in measured characters is far greater when the castes or tribes belonged to the same group than when they belonged to two different groups. One very well marked group consists of the two criminal tribes, Bhatu and Habrus. Another highly differentiated group is made up of Basti and other Brahmins. Ahir, Kahar, Kurmi and other artisan classes form a third group while Chero, Panika, Rajwar, Majhi, Khanwar, Chamar, Oraon etc., form the fourth group.

The classification reached by a purely statistical analysis of anthropological measurements is in general accordance with the known social status of the castes and tribes belonging to the above 4 groups. Muslims, Agharias and Chatris showed mixed characteristics and broadly resembled to some extent the second and the third but not the first or fourth groups. The position of Bhatu and Doms were also uncertain falling somewhere between the third (artisan) and the fourth (tribal) groups.

9. The use of wooden coffins in the Vedic period.

A. AIYAPPAN, Madras.

The use of a wooden chest for burial among the Kaffirs of the Hindu Kush—Sayana's gloss for *Vrksha, petika*. Evidence of ancient Hindus using coffins from the *Mahāparinibbāṇa Sutta*—representation of the Buddha's coffin in Gandhara sculptures.

The wooden coffins of Karans and other Burmese tribes, and their terracotta parallels from Maski (Hyderabad). Evidence of similar practices from Hindu Bali and from New Zealand.

On theoretical grounds there is no improbability of the *Vrksha* of the hymns being a wooden coffin.

10. On Roman Coins discovered in the village of Eyyal near Vadakkancheri in Cochin State.

P. ANUJAN ACHAN, Trichur.

In pursuance of the Diwan's D.O. No. 53/1121 dated 28th October 1945, and with a view to collecting correct information with regard to the discovery of the gold and silver coins reported by the Commissioner of Police on 19th October 1945, I first made inquiries in the Office of the Commissioner of Police, Trichur, on 30-10-45, after which I proceeded to the Erumapetty Police Station, and thence to Vadakkancheri,

2. I was shown at the Police Commissioner's Office a highly eroded silver coin got from the hoard of coins discovered at Eyyal. It contained the head of a Roman Emperor with the mark *Caesar* written on one side in Roman script.

3. I gathered from the Police Station at Erumapetty that the treasure was discovered a place not far from the prehistoric burial caves at Eyyal (about 10 miles from Vadakkancheri). The coins were deposited in an earthen jar which was found at a depth of two feet below the surface while digging a trench for planting bananas. The jar itself was broken to pieces and no trace of it has been seen so far.

4. I made a casual examination of the coins at the Vadakkancheri Police Station, in the presence of the Inspector of Police. There were one hundred and twenty coins in Police custody, of which twelve were made of gold and the rest of silver. All the and more than half of the silver coins, had impressions of the busts of early Roman Emperors, with writings in Roman script. About a dozen of the silver coins had punch-marks on them, while a few others were plain, carrying no marks or impressions on the surface.

5. A study of the writings on the coins has revealed that nine of the gold coins are of either Augustus or Tiberius, and three are of Nero. Of the silver coins, two are definitely that of Caesar; and the rest are of one or other of the early Roman Emperors. The latest coin is an *aureus* of Trojan.

6. The few punch-marked coins in the hoard, though they cannot at present be ascribed to any particular date or locality, may be referred reasonably to the same period as the gold and silver coins of the Roman Emperors. At least in two of the punch-marked coins, I have observed figures resembling the Greek *Caduceus*. They might perhaps be later imitations of the early Greek or Indo-Greek punch-marks, at one time current at Taxila or North-West India.

7. Sewell, writing in the Journal of the Royal Asiatic Society, 1904, has reported the discovery of Roman coins in India in abundance, especially in the North-West, and in and near the Coimbatore District and at Madura. Those picked up in South India, according to Sewell, pertain to the period commencing with Augustus and ending with the death of Nero, i.e. from 27 B.C. to 68 A.D. Vincent Smith in his Indian History, p. 141, writes, "Imported Roman Coins have been often found in the Punjab, Kabul, and neighbouring territories. In Peninsular India the Roman *aureus* circulated as currency, just as the British sovereign now passes current in many lands." In the Periplus, p. 204, Wilfred Schoff observes, "Roman Coins, of the reigns of Tiberius, Claudius and Nero, are known to have been found at Cannanore, in Northern Malabar."

8. It is indeed noteworthy that none of the writers has observed so far the existence of any Roman coins in Cochin State, a hoard of which has now been discovered for the first time in Cochin's history. This is only another proof of the extensive trade that Rome is believed to have had with Cochin in the early period of the Christian era.

11. Dress and ornaments of females as made out from the ancient Chalukyan sculptures of Badami, Aihole and Pattadakal.

R. S. PANCHAMUKHI, Dhārwar.

The monuments of Badami, Aihole and Pattadakal in the Bijapur District, Bombay Karnatak furnish a mine of information on the cultural life of Karnatak in the 6th to 8th century A.D. In art and architecture, sculpture and painting, they contain the best specimens covering a variety of interests—social, political and religious—and thus lay out our knowledge about the life and conditions of the people on a firm footing. The information thus gathered is corroborated by the statements contained in the lithic documents of the contemporary period, found in and around the locality.

In the present paper, an attempt has been made to study the female sculptures from the iconographical and anthropological points of view. The women depicted in stone in the early Chalukyan art can be ascribed to all grades of society—from the divine and royal to the peasantry and menials. Further, they show by their anatomical features, dress, ornaments and a peculiar mode of braiding their hair, a wide mixture of different racial habits and nationalities.

Badami and Pattadakal the Chalukyan metropolis and Aihole the chief trade emporium afforded a homely shelter to peoples from distant regions such as Malabar, Tamil land, presumably also Ceylon, Java and Sumatra as well as the Northerners up to Perisia.

A study of the ornaments and dress through centuries also exhibits the artistic taste and fineness of workmanship of the artisans of the Early Chalukya period. From

the shape and kinds of ornaments and the modes of dressing, it may be surmised that the social life of Karnatak being amenable to influences of the contiguous nations in the North and South of India preserved the best traditions of the period. A peep into the habits of hill tribes and hunting races can be gained from the study and analysis of the sculptures made in the body of the paper.

12. The age of the microlithic culture in Gujarat.

H. D. Sankalia, Poona.

Microliths have a very wide distribution in India. Most of these are surface finds, and are considered not older than 200 B.C. Excavations at Brahmagiri (Mysore), Naushahra (Punjab) and Langhnaj (N. Gujarat) have, however, given evidence for an earlier dating of this culture. At Langhnaj a large number of microliths have been found in unstratified loessic sand in association with a similar number of animal bones and seven human skeletons. According to chemical and other tests these bones are found to be considerably fossilized; much more than those found at Mohenjodaro and the sub-recent animal remains from the Patwar loess, though less than the Siwalik fossils. The microliths also comprise a few micro-burials. Besides these were also found an axe-head of quartzite, with a hole in the middle, splayed from both ends, and a small, polished celt-like implement of chlorite schist, and bone tools, (one very large, and the rest tiny). So on the evidence of (a) typical microlithic-early neolithic tools, (b) bone implements, (c) nature and degree of fossilization of the bones, and the total absence of metal objects and rarity of potsherds, it is held that the Gujarat microlithic culture is much earlier than the Indus Civilization, though its exact position after the Palaeolithic culture (in Gujarat) cannot be determined at present, nor can it be equated with the mesolithic cultures of Europe and Africa.

SECTION OF MEDICAL AND VETERINARY SCIENCES

PRESIDENT : RAI BAHADUR K.N. BAGCHI, M.B., B.Sc., D.T.M., F.R.I.C., F.N.I.

A. MEDICAL RESEARCH

Biochemistry, Nutrition and Public Health

1. Effect of different fats on calcium utilization in human beings.

K. P. BASU and H. P. NATH, Dacca.

Influence of dietary fat on calcium utilization has received considerable attention in recent times. All the investigators, however, have worked with rats and have shown that addition of fat to a fat-free diet has often a favourable influence on calcium utilization but opinions differed as to whether all the fats and oils were equally efficient for this purpose. The aim of the present investigation was to find out by direct experiments on human subjects whether there was any relation between the nature of the oil fed and the total amount of calcium and phosphorus absorbed.

The procedure adopted was to feed normal healthy adults on diets in which different oils and fats, e.g., mustard, coconut, groundnut, sesame, buffalo-butter fat and cow-butter fat were used, as the dietary fat and the intake and excretion of calcium and phosphorus were then measured according to standard methods.

The investigation goes to prove definitely two things: (1) firstly, the presence of fat in the diet greatly favours the absorption of calcium and phosphorus in the body. (2) secondly, all fats are not equally efficient in bringing favourable calcium absorption and indeed coconut oil exerts an antagonistic effect on absorption of calcium. Probably some particular calcium soap that is being produced in the intestine as a result of the digestion of the oil is not absorbed.

2. Comparative value of butter fats and vegetable oils for growth.

K. P. BASU and H. P. NATH, Dacca.

Comparative nutritive values of different fats and oils, e.g., mustard, coconut, sesame, groundnut oils and cow-butter and buffalo-butter fats so far as their effect on growth promotion of albino rats is concerned has been determined. A series of diets of the composition, ether-extracted egg-protein 10, salt mixture 4, agar 1, sucrose 9, calcium carbonate 1, fat 6 and starch 69 (in which the fat fraction was different in different groups) was made and fed to respective groups of rats one month old and weighing 40-50 gms.

Following is the result of the growth promoting effect of different fats and oils (measured as increase in weight per week per gm. of fat ingested) mustard oil 1.54; coconut oil 1.49; sesame oil 1.32; groundnut oil 1.79; buffalo-butter fat 1.98 and cow-butter fat 2.25.

From the results it is clear that that of all the oils studied butter-fat induced maximum growth.

3. Alloxan diabetes.

SACHCHIDANANDA BANERJEE, Calcutta.

Alloxan, ureide of mesoxalic acid, when injected parenterally has been found to cause selective necrosis of the islets of Langerhans in laboratory animals such as rats, rabbits and dogs leading to diabetes in these animals. It has been suggested that possible defects in the metabolism of purines or of alloxan in man might play some role in the etiology of diabetes mellitus.

The author has studied the action of alloxan in monkeys. Some experiments have been carried out in rabbits to explain the mechanism of action of alloxan. A method of estimation of minute amounts of alloxan has also been evolved. The method depends on the condensation of alloxan with 1,2-dimethyl-4-amino-5-(d-1-ribitylamino)-benzene yielding riboflavin. The riboflavin so produced is measured quantitatively by its fluorescence and by its growth-promoting properties for *Lactobacillus casei*. The results obtained will be discussed.

4. Changes in the serum protein in liver disease and other diseases : A comparative study.

S. T. ACHAE, Madras.

Variations in the serum albumin and globulin levels in cirrhosis of liver have been observed by several workers in recent years. In this paper the serum protein analysis of 17 cases of cirrhosis of liver, 5 cases of infective hepatitis, are compared with similar analysis in cases of cardiac cirrhosis, post dysenteric ascites, chronic nephritis, nutritional oedema, peptic ulcer, chronic ulcer of leg, and the following conclusions arrived at :—

(1) The serum albumin is almost uniformly lowered among the cirrhosis liver cases, but only in 2 of the infective hepatitis cases in this series. It is also found lowered in the few cases of nutritional oedema, post dysenteric ascites, cardiac cirrhosis and chronic nephritis that were studied in this series. Similar but less marked reduction is found in the series of Major Shoppard's cases of chronic ulcer leg at Vizagapatam, and in a large percentage of the "sick starving destitutes" in whom the blood protein analysis was done in the Calcutta School of Tropical Medicine.

(2) The level of serum albumin in cirrhosis liver seems to have a prognostic value from correlated study of the clinical and biochemical data.

(3) Alb/Glob ratio was altered in all but one of the series of cirrhosis liver cases. This reversal was found only in 1 of the 5 cases of Infective hepatitis studied. Similar reversal is found in the case of nutritional oedema, cardiac cirrhosis and in Major Shoppard's series of cases of chronic ulcer of leg.

(4) There was no constant or significant alteration in the level of Fibrinogen in the cirrhosis liver cases.

Finally a comparative study is made of the data in these investigations with similar data published by others previously.

5. Midday meals for school children—a comparative study.

C. O. KARUNAKARAN and R. MUKUNDAN, Trivandrum.

The progressive spread of education in Travancore was found to be accompanied by a rise in the number of school children who had no midday meals. A scheme has been introduced to provide free midday meals to poor school children and about 10,000 children are daily given a simple cheap meal consisting of rice gruel, and curry. It is expected that in the course of the next five years about a lakh of children of primary schools will be given free meals.

An experiment has been carried out to assess the nutritive value of the free midday meals given to school children in the primary schools of Travancore and to compare the results with possible alternative meals. Observations during a period of 6 months showed that the group which got 8 ounces of milk at noon gained more in height and weight than the other groups. The children on milk looked healthier. Phrynoderma which was the most common deficiency disease among all the groups appeared to be better controlled in this group. Milk is prohibitively costly and its use on a large scale is impracticable. But if soya bean milk has 90 per cent biological value of cow's milk, it holds out great possibilities for large scale feeding of school children at very low cost.

The *conjee* and curry now given to poor school children found to be useful in maintaining the health on a higher level than that of the better class children who went home for their midday meals.

Avad-flaked rice, with small quantities of boiled green gram, coconut scrapings and jaggery gave very satisfactory results consistent with cost. This preparation alone or in combination with soya bean milk might be very helpful in the provision of free school meals at reasonable cost.

6. Diet changes due to food scarcity and their results.

C. O. KARUNAKARAN and R. MUKUNDAN, Trivandrum.

The only common cereal food of Travancore is rice, 60 per cent of which was normally imported from Burma. The most striking change in the diets of the people resulting from war scarcity was a lowered consumption of rice, a partial substitution of rice by wheat and bajra, and an increased intake of root vegetables. The effect of these changes was studied in a controlled population—the inmates of the Central Prison, Trivandrum, where the ration of rice was reduced to less than 50 per cent of its former level.

The diets before and after the change were surveyed and the food factors and calory value estimated. It was found that by appropriate additions a drastic reduction of rice could be effected without lowering the quality of the diet. The effects of the new diet in the health of the inmates, studied for a period of 9 months, showed that the altered diet was helpful in maintaining weight and that the incidence of deficiency diseases and mortality were lower.

It appears that the intake of rice can be reduced considerably if millets and vegetables are taken in sufficient quantities and that the altered diet will be more balanced and cheaper. But opposition to diet changes is deeprooted and any change will require intensive and sustained propaganda.

7. The state of nutrition and physical development of school children of Hyderabad State.

M. B. DAVER, Hyderabad-Deccan.

This survey of nutrition and physical development is based on the study of 18,000 school children of both sexes in Hyderabad State, which for the purpose of the survey has been divided roughly into two large areas, according to the nature of cereals consumed—*jawar*—eating and rice-eating areas.

The diet of *jawar* eaters is better than those of rice eaters, inasmuch as they take milk and vegetables and pulses in greater amount. This factor has great influence on the incidence of deficiency diseases and physical development. The percentage of deficiency diseases amongst *jawar* eaters is decidedly less than in rice-eaters, and have better physique.

Hindoo of *jawar* and rice eating areas are shorter and lighter than Mohammads of the respective areas and belonging to same age and economic groups.

Hindoo and Mohammads of *jawar* eating areas are taller and heavier than Hindoo and Mohammads of rice eating areas.

From this we can conclude that even a slight difference in diet on better side, gives better physique, and perhaps *jawar* is, more nutritious than rice.

8. A report on the incidence, distribution, and epidemiology of filariasis in the central portion of H. E. H. the Nizam's Dominions.

M. FAROOQ and M. QUTUBUDDIN, Hyderabad-Deccan.

Twenty-two villages of Kamareddy and two of the Sirsilla taluks situated in the centre of Hyderabad State were surveyed in order to determine the filarial endemicity in this area. Over seven hundred blood smears were obtained to reach some conclusion with regard to the actual endemicity for which a special formula has been deduced.

A complete mosquito survey was carried out. 23 species of *Megarhinne*, *Culicine* and *Anopheline* mosquitoes were collected and dissected. *C. fatigans* was detected to be the vector species.

The filarial disease in any of the villages is not apparently so high but yet the endemicity rate in some villages is sufficiently high to call for immediate attention of the Sanitarian.

Neither of the sexes is more remarkably predisposed to the disease.

The infection rate does not show any relation with the advancing age.

The filarial infection rate in apparently healthy persons is higher than in the diseased persons where it is almost nil. Earliest occurrence of filarial infection was recorded to be at the age of seven. The infected persons are capable of transmitting disease only as long as they are apparently healthy.

The predominant infection is *Mf. bancrofti*.

15. Chronic amoebiasis.

A. K. M. ABDUL WAHED, Calcutta.

Vast literature has grown on this subject but still there is scope for discussion. The diagnosis of chronic amoebiasis appears to be the shelter to cover many chronic and vague abdominal diseases. The symptoms in chronic amoebiasis are mainly gastro intestinal and abdominal but neurotic symptoms are quite common and usually referred to other systems of the body.

It is a common condition in Bengal affecting both the Bengalees and the foreigners. The conditions with which this disease is confused are the chronic forms of hepatitis, cholecystitis, cholelithiasis and peptic ulcer (gastric or duodenal) — stress being laid on the last one. Chronic amoebiasis is sometimes complicated by the presence of chronic peptic ulcer and gall bladder troubles.

Prognosis is discussed. There is a dread attached to this disease in the minds of the Europeans resident in India but it is not justifiable.

Modern methods of treatment are discussed. Vitamins A, B₁, B₂ etc. have definite place in the treatment of such cases. Diet plays an important part—stress being laid on the use of meat and *Sandesh*. Neurotic symptoms deserve special attention; mental make up of the patient is to be understood, explanation and reassurance to be given.

16. Investigations into an outbreak of epidemic dropsy.

K. MITRA and K. K. P. NARASINGA RAO, New Delhi.

An outbreak of epidemic dropsy amongst the railway employees in Dinapore and other places in Bihar was investigated. The causative factor was found to be one particular sample of mustard oil which gave positive nitric acid test. The outbreak was characterised by sudden onset of frequent loose stools with sense of discomfort in the abdomen and persistent gurgling. This was followed by oedema for the limbs, flushing of the skin, vague and ill-defined pains all over the body and sometimes in the neighbourhood of joints. In some cases the oedema started first and the bowel trouble afterwards and in a few others there was no digestive disorders noticed. There was marked loss of appetite, fullness after one or two mouthfuls when sitting at a meal. One interesting feature was that a good majority of patients between the ages of 20 and 40 years complained of impotency. The investigation was carried out by house to house visits in 139 families. About 75% of male and 65% of female adults were affected. Amongst the children a positive correlation was noticed with age and percentage incidence, which varied between 17% in children under 2 years and 61% in children between 12 to 14 years of age.

17. Toxic manifestations of mepacrine hydrochloride in clinical practice.

AMULYARATAN CHAKRAVARTI and ANANTA LAL MISRA, Calcutta.

1. Some of the toxic manifestations and abnormal signs in its clinical use in 258 cases have been discussed :—

- (i) Pigmentation—15 per cent. Other associated troubles.
- (ii) Mepacrine psychosis—0.2 per cent. Other ill effects.
- (iii) Occurrence of nausea and vomiting, with or without pigmentation—22.3 per cent. Their course and termination.
- (iv) Nausea, vomiting and purging with or without pigmentation—4.2 per cent. Other ill effects.
- (v) Severe pigmentation, with nausea, vomiting, severe constipation, drowsiness and then unconsciousness, anuria and other toxic symptoms and death of only 1 case.

2. Mepacrine as an absolute antimalarial drug. Combination of quinine and mepacrine—advantages and disadvantages. How far useful against relapses.

3. What are the remedies to cut out the complications and how to manage the 'dread' against the 'Yellow Drug'.

18. A note on mepacrine psychosis.

NAGENDRANATH DE, Calcutta.

8 cases of mepacrine psychosis are reported. The incidence of such psychosis among the total number of patients taking the drug is about 0.8%. The mental symptoms are of 3 different types : (1) excitement of manic type, (2) schizophrenic type and (3) confused type—confused and delirious—unable to recognise even near relatives.

19. Clinical toxicology of *Rauwolfia serpentina*

NAGENDRANATH DE, Calcutta.

Rauwolfia serpentina has no official dose. It has been used for a long period in indigenous systems of medicine. Recently it is being largely used in cases of high blood pressure and some mental diseases. The dose used for high blood pressure is about 70-100 grains of the powdered root daily or the corresponding amount of total alkaloids or liquid extract. The dose for mental diseases is about 3 times as much. Toxic symptoms are sometimes observed with these therapeutic doses.

Parkinsonism is one of these toxic symptoms. Bradycardia and congestion of face, conjunctivae and nasal mucous membrane are others. Bradycardia is probably due to depressing action of some of the alkaloids on the innervation and musculature of the heart. The cause of the other toxic symptoms is not known. Parkinsonism has been found very commonly among workers in manganese mines and factories. *Rauwolfia* roots are also found to contain a fair amount of manganese. Whether the Parkinsonism in the above cases is due to the manganese content of the roots is worth further investigation.

20. On the clinical use of sulfabenzide (sulphanilyl benzamide) intestinal infections.

AMULYARATAN CHAKRAVARTI and ANANTA LAL MISRA, Calcutta.

Sulphanilyl benzamide has already been reported to be an effective remedy against bacillary dysentery. Its relative low toxicity and its efficacy in comparatively smaller dosage are noteworthy. Considering that the previously reported anti-dysenteric remedies, such as sulphaguanidine or sulphapyridine, require a very heavy dosage which frequently gives rise to untoward reactions, it was considered worth while to try the efficacy of sulphabenzide (sulphanilyl-benzamide) in the treatment of various intestinal infections. The cases selected for this investigation covered a wide range of conditions—typical bacillary dysentery, children's diarrhoea, acute and chronic colitis and a few cases of cholera. A total of 75 cases have been treated during this investigation. It has been noted that in typical bacillary dysentery and in children's diarrhoea, the drug acts almost as a specific. In cholera, when given along with saline, the drug definitely exerts a beneficial effect. In cases of colitis, however, particularly in chronic cases, though improvement of the cases occur, after a course of administration of sulphabenzide, the effect of treatment is not maintained for a long time. It is now being tried after eliminating the other pathological causes of colitis so as to allow the drug to exert a more permanent effect.

21. On the action of sulphanilyl benzamide.

U. P. BASU, J. SIKDAR and P. SEN GUPTA, Baranagar (Calcutta.)

It is generally agreed that the sulphonamide type compounds act by competing with *p*-amino benzoic acid for an essential enzyme system of the pathogenic organism. For exerting the maximum physiological action the compound, however, should be present both in ionic as well as in undissociated molecular form as it is the latter only that can penetrate through the cell membranes. In working with N_1 -benzoyl sulphanilamide (sulphanilyl benzamide) and its various N_1 -derivatives it is being noticed that their bacteriostatic action at least against intestinal organisms seems to be dependent on the physical characteristics of the compounds. The mobility of the replaceable N_1 as well as N hydrogen atom plays an important part in controlling the action of the compounds in question.

22. The action of sulphanilyl benzamide against streptococcal infections in mice.

A. N. ROSE and J. K. GHOSH, Baranagar (Calcutta)

Sulphanilyl benzamide has previously been reported to be well absorbed from the gastro-intestinal tract and to maintain a high and steady concentration in the blood of mice and rabbits (Rose and Ghosh, *Ind. Jour. Med. Res.*, 1944, 32, 61). It has also been observed to have a definite anti-pneumococcal activity of as well as to exert marked therapeutic action in bacillary dysentery (Sweyer and Yang, *Brit. Med. J.*, 1945, i,

149; Bose and Ghosh, *Ind. Med. Gaz.* June, 1945). In continuation of these works, investigations have been carried in this laboratory, to study its protective action, if any, against streptococcus haemolyticus (Richard's strain) infections in mice in comparison with sulphanilamide. The drugs were fed orally, as well as administered in diet. The results of the study indicates that sulphanilyl benzamide possesses anti-streptococcal activity as powerful as that of sulphanilamide.

23. Anti-bacterial action of chlorophyll.

A. B. BOSE and P. N. SEN GUPTA, Baranagar (Calcutta).

Recently it has been shown by Smith (*Jour. Amer. Med. Sci.* 1944, 207, 647) that water-soluble chlorophyll derivatives having no direct action upon the bacteria themselves exert a bacteriostatic effect by producing an unfavourable environment for bacterial growth. They are not toxic too. As a matter of fact in India the juice from certain leaves of *Gandha* (*Tagetes patula*), *Shial kanta* (*Argemone mexicana*) and *Apang* (*Achyranthes aspera* Linn) are often used topically against cuts and wounds. An investigation on the nature of the principles as present in the juices of the fresh leaves and twigs of the above plants, and their action on certain pathogenic organisms has been undertaken in this laboratory.

The coloured pigments (chlorophyll) as present in the fresh leaves of the above plants were isolated in a concentrated form almost according to the process as described in Onslow's Practical Plant Biochemistry, 1929, p.29). The different purified extracts were tested for their bacteriostatic action against *Staph. Aureus* and *Strep. Haemolyticus* in beef infusion broth. The former was inhibited by 1 : 40 dilution but not by 1 : 80, and the latter inhibited by 1 : 80 but not by 1 : 160 dilution of the different concentrates containing about 0.1 per cent solid. In the case of *Apang* extract we noticed an inhibition zone of 13 mm. diameter against *Staph. aureus* by the agar-cup method. None had any inhibitory effect on *B. typhosum*.

24. Therapeutic uses of sea-water : Effects of sea-water injections on scabies

J. S. CHOWHAN and N. MONEY, Bangalore.

This is an investigation on therapeutic uses of sea water, particularly on its effect in scabies which is a very common skin disease met with in civil and military hospitals. Sulphur is usually the drug of choice in scabies, but the dearth of this drug during the war compelled the medical officers in the Army to try various other substances. Sea-water was used by the author in treating successfully quite a large number of cases of scabies. It was given by the subcutaneous route in doses of 1-2 c.c. In most cases the result was quite satisfactory. The investigation is on progress. A trial may be given to this simple and inexpensive substance by medical men who happen to get cases of scabies for treatment.

25. On the mode of action of dicoumarin.

A. N. BOSE, Baranagore, Calcutta.

Since the isolation of 'Di-coumarin' (3.3' methylene bis (4-hydroxy) Coumarin, by Link *et al* (1941)), large number of investigations have been carried on its mode of action with particular reference to its physiology, toxicology and therapeutic effects. It is generally accepted that 'Dicoumarin' acts by interfering with the production of prothrombin from the liver. During the course of studies carried with the drug, prepared in this laboratory, it was observed that the thromboplastin content of the brain from animals having died after heavy doses of 'Dicoumarin' was definitely below that obtained from the normal brain of untreated rabbits. Extravasation of blood was also observed in the peritoneal cavity of the animals. Accordingly, further investigations have been carried on the determination of prothrombin time with haemoplastin preparations from the brains of normal as well as that of Dicoumarin-treated animals. These investigations show that the haemoplastin prepared from drugged animals is definitely of inferior strength than normal haemoplastin. Red-cell fragility determinations, carried out along with this study, show no abnormal increase in the fragility in treated animals. It is suggested that the deficient formation of thromboplastin from the system may also be an additional cause for the increase in prothrombin time in animals after feeding with Dicoumarin.

26. Effect of sulphadiazine on experimental animal plague.

J. C. GUPTA, G. PANJA, and M. CHATTERJEE, Calcutta.

Sulphadiazine (300-400 mgms.) was administered in 3 groups of guinea-pigs, 5 in each, inoculated with a lethal dose of *Pasteurella pestis*. In one group, the drug was given orally immediately after the inoculation and continued twice a day for three days. In another group, the drug was started 48 hrs. after inoculation and continued in the same way. The third group was kept as a control without giving any drug. In another group of 2 animals, the drug alone was given to test its toxicity and no inoculation with *pestis* was done. At the same time 3 groups of animals were inoculated with the organism and then injections of penicillin were given. The result of all these experiments show that in the control plague animals and animals inoculated with penicillin, death occurred in from 2 to 7 days. Characteristic lesions of experimental plague were seen, numerous plague bacilli were found in the lesions and isolated in pure culture. In the sulphadiazine treated animals no plague bacilli were found either by film examination or by culture, although most of the animals died later due to accidents in feeding onset of pneumonia. Sulphadiazine was thus found efficacious in sterilising plague injected experimental animals whereas penicillin proved to be a failure.

27. Comparative action of trypsin on amorphous insulin, crystalline-Zn-insulin, protamine-Zn-insulin and globin insulin.

N. K. IYENGAR and B. MUKERJI, Calcutta.

The comparative action of trypsin on amorphous insulin, crystalline-Zn-insulin, protamine-Zn-insulin and globin-insulin has been studied by following both the inactivation of insulin as well as the increase in non-protein-nitrogen, the latter result being expressed as so many mgms for 100 mgms of insulin. The rates of inactivation of insulin as well as the digestion of insulin protein are in the order of (1) amorphous insulin, (2) crystalline-Zn-insulin, (3) globin and (4) protamine-Zn-insulin.

Protamine has been found to be an inhibitor of the tryptic digestion of casein at pH 7.2.

The inhibitory effect of protamine is noticed even when it is directly added to the enzyme-substrate mixture, unlike the other two inhibitors, (i) polypeptide from blood and (ii) Heparin, both of which have to remain in contact with the enzyme for a period of 30 minutes before the substrate is added.

This important difference between Protamine on the one side and the other two trypsin-inhibitors on the other side accounts for the inability of the latter two substances to exert any significant prolongation effect when mixed with insulin and injected to rabbits.

The results reported in this paper lend strong evidence in support of the hypothesis that the prolongation effect of certain insulin preparations is either due to the inhibitory effect of the non-insulin constituents on the physiological tryptic destruction of insulin or due to the partial protection offered by other proteins like globin against the tryptic digestion of Insulin.

28. The evaluation of various transfusion agents in hemorrhagic shock.

B. MUKERJI and N. K. DUTTA, Calcutta.

With a view to study the comparative replacement value of Ringer's solution, hemoglobin Ringer solution, gum saline solution (Bayliss formula), liquid processed human serum, liquid processed human plasma, etc., in shock, an artificial hemorrhagic shock was brought about in anaesthetised cats by slow massive hemorrhage from a carotid artery. The respiratory rate was kept constant by regular inflow from an artificial Palmar pump. When the blood pressure of the animals had fallen to 25 mm. Hg or less (terminal stage), transfusions of Ringer saline, human serum and human plasma were given and the resuscitation effects of these were carefully observed. In each instance the volume transfused was equal to the volume of blood removed.

In these experiments saline produced no permanent recovery and similar findings were also recorded for hemoglobin Ringer solution. Gum saline raised the blood pressure to almost pre-shock level but recovery rate of the animals was not as good as in the cases of human serum and plasma. Liquid processed serum, as prepared in the 'Blood Bank' of the All India Institute of Hygiene, kept up the blood pressure well after transfusion, brought back the rectal temperature to pre-shock level and improved in general

the condition of the animals. Reactions were noticed in a few cases which were ultimately traced to defective handling or transportation of the blood from which serum was processed rather than to any inherent defect in the physicochemical balance and resuscitative properties of the serum.

29. Is chloral hydrate toxic to the cardiac musculature ?

B. MUKERJI, Calcutta.

The traditional pharmacologic concept about chloral hydrate is that it is toxic to the heart and that it brings about cardiac muscular paralysis in generous dosages. In connection with a series of experiments undertaken to measure the excretion of free chloral in the urine (as distinguished from trichloroethyl-glucuronic acid or urochloralic acid, in which form it is largely excreted), it was necessary to give rather heavy doses of chloral hydrate to dogs (200 mgm/kg.), maximal human dose being 4 gm. or about 66 mg/kg. in a 60 kilo adult. The chloral concentration of the blood reached within 40-50 minutes as high a figure as 3.82 mgm/per cent and animals were under deep somnolence with a definite slowing of the respiration.

Myocardiographic tracings taken at this stage of 2 dogs (6.0 to 6.3 kilo weight) showed no noticeable diminution in the amplitude of the auricular and ventricular beats as compared to normal dogs under chloralose anaesthesia. There was a fall in blood pressure but this was not significantly lower than a fall brought about by any other commonly used anaesthetic of the chloralose or barbiturate type. Electrocardiographic studies were attempted in collaboration with a Calcutta cardiologist but beyond one successful experiment, this study could not be successfully carried out. The only successful experiment indicated hardly any change indicating myocardial depression with a somnolence-producing dose of chloral hydrate.

These studies tend to counter the belief that chloral hydrate is a true myocardial depressant drug. The slowing of respiration fall of systemic blood pressure and dilatation of superficial vessels are due more likely to vasomotor paralysis rather than to direct muscular inhibition.

Microbiology and Immunology

30. Organisms in the healthy duck's and hen's eggs.

C. L. PASRICHA and G. PANJA, Calcutta.

200 duck's eggs and 100 hen's eggs were examined. The surface of the eggs was sterilised by pure phenol followed by 70 to 75% alcohol and subsequent flaming. In some lots electrolytic chlorine was used in place of phenol. Efficiency of sterilisation was tested by applying a thick coating of known cultures of various organisms. About 70 per cent eggs were found aerobically sterile. In about 10 per cent of the eggs, an organism very similar to *Bacterium faecalis acaligenes* was found in pure culture and this organism was most frequently isolated. Besides this, non-agglutinating vibrios, coliform organisms, *Pseudomonas pyocyanea* and *fluorescens*, *Bacterium asiaticum*, Proteus, Staphylococci, spore-formers and certain other organisms were isolated. Salmonella organisms were not found. The ways that these organism could gain access into the eggs are (1) in the oviduct during the development of the eggs; (2) during the process of laying of eggs and or (3) during subsequent handling and storage. The egg shell was also demonstrated to be highly porous and was permeable to vibrios and salmonella organisms from outside under pressure.

31. A new method of demonstrating malarial parasites in the peripheral blood.

H. N. CHATTERJEE, Calcutta.

(1) By means of supravital staining the malarial parasites can be sharply stained and easily found out. The stain consists of Leishman's stain 2 parts, brilliant cresyl blue 1 part (1% alcoholic solution).

(2) The method eliminates fixing, dehaemoglobinisation, drying, changing of stains and washing.

(3) Reticulocytes may be counted at the same time.

(4) It is a better contrast stain than the usual Romanowsky methods.

(5) There is no distortion of the corpuscle or parasites as is found in thick smears.

(6) It is a very suitable method for mass examination of blood as in Outdoor Dispensaries, Relief centres etc.

32. Immunity after intradermal inoculation of cholera vaccine.

G. PANJA and N. N. DAS, Calcutta.

11 persons were injected intradermally at an interval of 7 days with 0.1 c.c. and 0.2 c.c. of a standard cholera vaccine and 10 persons by the current method with 0.5 c.c. and 1.0 c.c. subcutaneously. No agglutinins for the Inaba and Ogawa subtypes of cholera vibrios were found in all the 21 persons excepting in 2 in small titres of 1 in 10 and 1 in 20 before inoculation. The reaction after intradermal inoculation in the first group of cases was negligible. Blood was tested in all the persons for agglutinins one week after the last inoculation. The majority of the persons in the first group showed agglutinins varying from 1 in 40 to 1 in 160 or over, whereas the second group showed a titre from 1 in 40 to 1 in 80 only. In 3 persons of the second group there was no detectable agglutinin after the subcutaneous injection.

The sera of the above persons collected before and after immunisation were also tested for the presence of bacteriolysins and protective antibodies for cholera vibrios in guineapigs. In animals receiving pre-inoculation sera, no bacteriolysin was found in the peritoneal fluid as a rule and all the animals died but in all the animals protected with the post-inoculation sera of the first group (intradermal), lysis was present and 100% of the animals survived whereas in the animals protected with the post-inoculation sera of the second group (subcutaneous) poor lysis was present and 57% only of the animals survived. This shows the superiority of the intradermal method of inoculation over the current subcutaneous method in the following respects: (i) production of higher grade of immunity, (ii) less marked local and general reaction after inoculation, (iii) 5 times less amount of the vaccine used, and (iv) marked reduction in the expenditure of agar glass ampoules and labour.

33. Groundnut hydrolysate as culture medium.

A. N. SEN, S. SEN GUPTA and U. P. BASU, Baranagar (Calcutta).

In a previous work it was shown by us (*Ind. Med. Gaz.* 1945) that a hydrolysate may be obtained from ground nut meal by digesting the same with trypsin or papain. This serves as a good medium for the growth of various intestinal organisms. In the present paper it has been further shown that the hydrolysate mixed with liver extract is also a good medium for the growth of pneumococcus, streptococcus and meningococcus. Thus the ground nut meal that is being mainly used as fodder, may also be utilised in preparing bacteriological culture medium.

34. Transplacental passage of rabies virus from mother to foetus.

C. O. KARUNAKARAN and C. GOPALAN NAIR, Trivandrum.

(1) Conflicting views have been expressed by different workers about the possibility of the transmission of rabies from the mother to the foetus. Some of the relevant literature is briefly reviewed.

(2) Transmission of fixed virus from the mother to the foetus does not appear to occur.

(3) The blood of animals moribund from fixed virus or street virus infection is found to be free from virus and this might be the main reason for the failure of the transmission of infection from the mother to the foetus.

(4) The conflicting views recorded indicate the desirability of studying this problem utilizing modern developments in laboratory technique and accuracy.

35. Isolation of cholera vibrios in Hooghly river water.

G. PANJA, Calcutta.

524 samples of Hooghly river water were examined for vibrios by the candle-boric-peptone water method (Panja). Inaba and Ogawa sub-types of vibrios were isolated from 16 samples. On the other hand, non-agglutinable vibrios were isolated from the majority of the samples. Owing to the presence of large numbers of these non-agglutinable vibrios, agglutinable vibrios quickly disappear from the water. This has been proved by artificial experimentation. Agglutinable vibrios (Inaba and Ogawa sub-types) added to Hooghly river water which was already filtered through L_2 porcelain candle can be recovered sometimes up to the 3rd week but these vibrios are killed in 1 to 3 days if they are added to most of the unfiltered water. Artificial mixtures of agglu-

tinable and non-agglutinable vibrios in peptone water and nutrient agar slopes have also shown that vibrios of the latter group overgrow those of the former group causing the agglutinable vibrios to ultimately disappear from the mixture. It was mainly for this reason that cholera vibrios were not isolated so long from the river water. By practising the candle-boric-peptone water method it was possible to isolate the cholera vibrios from unconcentrated river water.

As cholera vibrios were found in the Hooghly water, it is highly possible that the use of unfiltered water may convey infection of cholera. This is corroborated by the yearly incidence of cholera in a well-to-do orthodox family of Calcutta, using the Hooghly water for domestic purpose.

36. Antigenic analysis of vibrios by observing motility in semisolid immune serum agar.

G. PANJA, Calcutta.

Several pure smooth strains of Inaba and Ogawa sub-types of cholera vibrios, El Tor vibrio and non-agglutinable vibrios—paracholera and saprophytic, both haemolytic and non-haemolytic were put up by stab culture in semi-solid immune serum agar deep. It was found that Inaba serum (H & O) arrested the motility of Inaba, Ogawa and El Tor vibrios but not of the paracholera and saprophytic vibrios. An Ogawa serum behaved similarly. On the other hand sera raised against non-agglutinable vibrios as a rule did not arrest the motility of Inaba, Ogawa and El Tor vibrios but arrested the motility of homologous non-agglutinable vibrios. It is therefore highly suggestive that the flagellar (H) antigens of cholera and El Tor vibrios are identical but these are different from those of non-agglutinable vibrios. Even amongst the several groups of non-agglutinable vibrios, H antigens appeared to be dissimilar. This finding is opposed to the view of Gardner & Venkatraman (1935) who are of opinion that the flagellar antigens of all vibrios—cholera and noncholera are the same. By the above mode of analysis, complete identity between two or more vibrios is established when cross tests are done and no out-growths from the stab line are visible and the vibrios are seen in small clumps in the stab line. Such an analysis has also suggested that a few non-agglutinable vibrios may possess some O—antigenic relationship with cholera vibrios.

37. A new additional method of potency test for cholera vaccine.

G. PANJA, Calcutta.

The new test consists in noting the presence of bacteriolysin after immunisation of guinea-pigs with the cholera vaccine. The advantages are that a smaller number of animals is required; the presence of bacteriolysin as well as of protective antibodies can be simultaneously tested in the same animals, affording thereby an opportunity of a double check on the vaccine; and the immunity test is elicited in 1 to 2 hours only after an assaulting dose. This test has also shown that a non specific cellular immunity produced by non-agglutinable vibrios and staphylococci, however high it may be, does not produce bacteriolysis and afford protection. It is the humoral immunity that appears to be more essential for bacteriolysis and protection. The test has also shown that there is no adequate bacteriolytic immunity four days after an immunising dose of the vaccine, that guinea-pigs are variable in their antigenic response to the vaccine and that vaccines not passed by agglutinability tests can still give rise to bacteriolytic and protective antibodies.

38. A comparative study of the incidence of bacillary dysentery among destitutes in Bengal during the famine of 1943 and after.

S. K. GUPTA, Calcutta.

In 1943, 268 samples of stools from clinically diarrhoea and dysentery cases from three hospitals of Calcutta were examined with the following result :

Bact. flexneri was isolated in 46 cases or 17.1%.

Bact. shigae was isolated in 5 cases or 2%.

Bact. schmitzi was isolated in 3 cases or 1.4%.

Thus out of 268 specimens of faeces, dysentery bacteria were isolated in 54 cases or 20.1%.

109 specimens of stools were examined only microscopically and no cultural examination was done in these cases. Out of these 67 cases, i.e., about 61% showed bacillary exudate.

In 1944, 682 specimens of stools from clinically diarrhoea and dysentery cases from three hospitals were examined microscopically only and cellular exudates of bacillary type were seen in 243, i.e., in 35.6% of cases. Suitable media being not available for all the cases, only 115 specimens of faeces were cultured in DEC and litmus-lactose-bile-salt media. *Bact. flexneri* was isolated in 11 cases and *Bact. sonnei* in one case. Thus dysentery bacteria were isolated in 10.4% of cases. Positive bacteriological findings were more common in Bengal during the starvation period in 1943 than in the non-famine period of 1944 as is evident from figures given above.

After a comparative study of litmus-lactose-bile-salt and DEC media (a modification of S S-agar) it was found that the DEC medium is far superior to litmus-lactose-bile-salt or MacConkey medium for isolation of intestinal pathogens.

39. Preservation of tetanus antitoxin by drying from the frozen state.

D. C. LAHIRI, Bombay.

Concentrated and purified tetanus antitoxin was dried from the frozen state by the method evolved by Strumia and others. It was stored at 37°C. A portion of the antitoxin was also dispensed in liquid form in ampoules, and stored under the same conditions as above. A few ampoules of liquid antitoxin were also stored at 0°C. The antitoxin titres of the samples were determined from time to time. At 37°C the liquid antitoxin had lost more than 50 per cent of its potency in 12 months and jellified subsequently. Even at 0°C., the liquid antitoxin had lost nearly 20 percent of its potency in 3 years. The dried antitoxin, on the other hand, showed no loss of potency even after 3 years of storage at 37°C. The dried antitoxin dissolved rapidly in water and formed a clear solution.

40. Bactericidal power of human serum and that of laboratory animals with special reference to *Pasteurella pestis*.

D. W. SOMAN, Bombay.

Bactericidal power of human serum and that of the laboratory animals were studied against a virulent strain of *Pasteurella pestis*. The method adopted consisted of mixing of an arbitrarily fixed quantity of serum with varying grades of *Pasteurella pestis* suspensions. The effects were studied at varying periods of contact from 24 hours to 192 hours. The mixtures were allowed to stand at 37°C and subcultures were taken in suitable media. Interesting results were observed. The sera of common laboratory animals failed to show any bactericidal properties with this method. Whereas some irregular exhibition of bactericidal power was noted with sera of rats and horses, human serum showed definite evidence of early and rising bactericidal activity. This activity was more pronounced at the later part of the period of observation. Studies were also made as regards the influence of age, the complement and the physical state of the sera in connection with their bactericidal properties. A case is made for the advisability of testing serum for longer periods than 24 hours to demonstrate in full the bactericidal power.

41. A preliminary study of six-hour rat test for pregnancy.

D. W. SOMAN, Bombay.

Since twentyfour rat test was shown to compare very favourably with the classical hormonal tests for the diagnosis of pregnancy, many attempts have been made to shorten the period of test still further and obtain reliable results. Experimental studies have shown that an immature white rat is equally sensitive to the hormonal response within a period of six hours, on the basis of which a study of six hour rat test for the diagnosis of pregnancy was made. One rat was used for each test and it received four c.c. of urine subcutaneously once only. The rat was killed at the end of six hours and the results were noted and compared with the results of Friedman tests or twentyfour hour rat tests. One hundred samples of urine were thus tested and the results described and analysed confirm the opinion that the white rat is a suitable experimental animal to replace the rabbit and that the test is rapid and reliable if used with caution by experienced personnel. A suggestion is made that a further trial be given to this test to assess its utility on a wider scale, as the rat offers certain and definite advantages over the mouse and the rabbit.

42. A comparative study of saponin-broth and bile-broth as a blood culture medium for isolation of enteric group of organisms.

D. W. SOMAN, Bombay.

With an opportunity of doing blood cultures at the bed-side, presented by the Typhoid Enquiry, it was decided to try saponin-broth as a blood culture medium for the primary isolation of the enteric group of organisms, in addition to the routine use of bile media. Saponin-broth was prepared as described by Penpto and his colleagues, who advocated its use for primary isolation of a number of different organisms, with encouraging results. Blood was inoculated into this broth and the bile-broth medium in equal quantities incubated at 37°C and subcultures were made at the end of every 24 hours for five days if negative and the results were noted. Blood cultures were tried in 52 cases and only in 16 cases, the enteric group of organisms could be isolated. The new medium could give only 50 per cent positive results when compared with the routine bile media. Thus, for primary isolation of enteric group of organisms, saponin-broth as a medium for culture offered no advantages over the routine ox-bile media.

43. Local treatment of infected experimental wounds.

B. V. PATEL, Bombay.

Sulphonamides have been used very widely both locally and internally for the treatment of infected wounds. Investigations were undertaken in our laboratory to prepare a suitable paste containing sulpha drugs producing a "water-in-oil" type of emulsion, which would be absorbed slowly from the site of application. A formula for the same has been perfected.

Pastes using six different sulphonamides (Sulphasuxidine, Sulphadiazine, Sulphaguanidine, Sulphamethiazine, Sulphanilamide, and Sulphathiazole) were made according to the evolved formula. The effects of these paste were studied on infected experimental wounds in rabbits. Sulphathiazole has been found to be the best drug for local treatment of infected wounds.

Toxicology

44. Preservation of post-mortem materials with saturated salt solution.

K. N. BAGCHI and H. D. GANGULY, Calcutta.

It was observed in certain cases of fatal poisoning (not by alcohol) that appreciable amounts of alcohol were present in the stomach contents consisting chiefly of half-digested rice and other starchy food although the history and post mortem signs did not indicate any ingestion of alcohol. In all these cases the samples of a salt solution used as preservative were found to be half-saturated or even weaker.

With a view to find out if the rice etc. present in stomach could undergo alcoholic fermentation, experiments with rice, gruel and different concentrations of NaCl at room temperature and in open jars were carried out with the following result : In 4-10 days 1% NaCl produced 0.46% alcohol, 8% NaCl produced 0.25%, 16% NaCl produced 0.22% and 24 to 32% NaCl produced no alcohol. No yeast nor any other fermenting agent was added.

Above facts indicate the importance of using saturated NaCl solution (32.7%) as a preservative. Use of weaker solutions is liable to result in alcoholic fermentation of stomach contents. A testotator dying of heart failure may in such circumstances be declared as an alcoholic.

45. Toxicology of tapioca or 'Simool Alu' (*Manihot utilissima* Pohl).

K. N. BAGCHI and H. D. GANGULY, Calcutta.

Tubers or fleshy roots of *Manihot utilissima* are taken in Southern India and lately in Bengal by poor people. Its cultivation on a large scale was encouraged in Bengal during the last famine. Tubers are usually 12" or more in length—the maximum diameter being 3-4 inches. The skin is thick and exudes a milky juice. It peels off easily after boiling in water.

As its juice has been known to be poisonous in Brazil, Guiana and other places, due to (HCN), an investigation to determine the nature of the HCN-compound was

carried out. Hydrocyanic Acid in the form of a cyanophoric glycoside was found. It is distributed in the tuber in the following proportions :

Skin—0.07% (head end) to 0.296% (tail end), Pulp—0.024% (head) to 0.12% (tail).

After boiling for 30 minutes in water in thin slices or in big lumps no hydrocyanic acid was detected either in the pulp or in the skin. It is therefore evident that the tuber if taken uncooked is likely to produce serious HCN poisoning but if taken after boiling or cooking, is harmless. In any case, the skin should be rejected. The sample for analysis was received from Madras.

46. Phenolic bodies in free and conjugated forms in tissues in health and in phenol poisoning.

K. N. BAGCHI and H. D. GANGULY, Calcutta.

In fatal cases of phenol or cresol poisoning, fair amounts of free phenolic bodies are found in the liver and other tissues. A portion of the phenols is conjugated to glycuronic and sulphuric acids and a portion is oxidised to form harmless compounds as a natural defence of the human system, and phenol is thus eliminated from the system in these forms. If death does not take place rapidly in cases of phenol poisoning, quite a large amount of the absorbed phenols is likely to be conjugated. This investigation has been taken up to find out how much free and conjugated phenols are normally found in the liver and other organs, and to determine the capacity of the system to convert free phenol into its conjugated forms in cases of fatal poisoning by phenol or cresol. This is a preliminary note and the investigation is in progress.

The amounts (milligrammes per kilo of fresh tissue) of free phenolic bodies found in normal liver and stomach (i.e., from persons of robust health died in street accidents) and those found in fatal cases of phenol poisoning are shown here :

	Normal tissues		Tissues from cases of phenol poisoning	
	Free phenol	Conjugated phenol	Free phenol	Conjugated phenol
Liver	19—30	62—124	108—141	315—410
Stomach tissue	nil— 7	18— 21	21— 45	60—135

Anatomy

47. On the anatomy of the human biliary tract.

A. M. KHAN, R. L. AGARWALA and P. D. SHUKLA, Lucknow.

A detailed knowledge of extra-hepatic-biliary tract is of great surgical importance. The gall bladder is described as situated behind the tip of the ninth right costal cartilage ; but the latter admits of individual variations and does not invariably bear such relation to the gall bladder. Further, there is no reason to expect any relationship between them on embryological grounds.

The present investigation is intended to locate the gall bladder with reference to a constant and easily definable landmark on the abdominal wall. Various relevant measurements have been taken on about 100 human bodies. Statistical analysis of these data has given encouraging results, e.g., it has been found that on an average the ratio between the length of the bile duct and the stature is 1 : 26. A number of anomalies also have been noted.

B. VETERINARY RESEARCH

Parasitology

48. On the validity of *Ixodiphagus mysorensis* Mani, a chalcidoid parasite of ticks.

S. R. RAO, Bombay.

Evidence is produced in this paper that *Ixodiphagus mysorensis* Mani, a chalcidoid parasite of ticks is not a valid species but is in reality referable to *Hunterellus hookeri*, Howard.

Pathology and Immunology

49. A preliminary note on vaccination against bovine contagious pleuro-pneumonia in Assam.

V. R. GOPALAKRISHNAN, Gauhati.

Details are given of the experimental vaccination carried out in two localities Gauhati and Kukuria in Assam, against bovine contagious pleuro-pneumonia.

Observations on the reaction following the inoculation of pleuro-pneumonia vaccine (culture-virus-vaccino), by tail-tip or Willems' method, are recorded.

A preliminary, small-scale experimental test of the vaccinated cattle, undertaken to determine the degree and duration of immunity by using a fresh field strain of the virus for the test, is described. There is evidence of sufficient degree of immunity, the duration of which appears to be near about 22 months.

Mention is made of a scheme for the control of bovine contagious pleuro-pneumonia in Assam, wherein the importance of systematic vaccination is stressed.

The methods adopted by workers in the Commonwealth of Australia, for vaccination of cattle and for testing induced resistance are discussed.

The work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research.

50. An interesting case of John's disease in a bullock.

G. R. VISWANATHAN, Madras.

This interesting case was recorded in a cross bred Ayrshire Seimthi bullock belonging to the Agricultural Research Station, Nanjanad, Nilgiris, aged about 9 years. The animal gave negative reaction to the Johnin test. Only once stray organisms (acid fast bacilli) were detected, and at other times were negative. The characteristic wrinkling and thickening of the mucous membranes noticed in all cases of John's disease were absent, but instead the mucous membrane of the intestines was pale and smooth, which is very rare. The examination of the smears from the intestines taken at random did not reveal *Mycobacterium paratuberculosis*, but the smears taken from the enlarged mesenteric lymphatic glands revealed innumerable *Mycobacterium paratuberculosis*.

This case is an interesting one since the lesions recorded are quite contrary to the usual characteristic lesions of wrinkling and thickening of the mucous membranes of the intestine, especially the ileum.

51. An interesting case of post-mortem in a bullock of the corporation of Madras.

G. R. VISWANATHAN, Madras.

The object of this note is to bring to the notice of the profession very interesting lesions of tuberculosis recorded in a bullock of 12 years in the Madras Presidency. The case is one of generalised tuberculosis. The post-mortem findings, particularly the grape like lesions all over the diaphragm, peritoneum and pleura and two hydatid cysts, one in the left lung and the other in the liver, are interesting. The grape lesions varied in size from small peppers to big walnuts. These lesions are common in Scotland but appear to be comparatively rare in this country, particularly in the Madras Presidency.

SECTION OF AGRICULTURAL SCIENCES

PRESIDENT : RAO BAHADUR V. RAMANATHA AYYAR, L.Ag., F.A.Sc.

Soil Chemistry

1. Studies on phosphate fixation by clay minerals*

J. N. MUKHERJEE, B. CHATTERJEE and S. DUTT, Calcutta.

Estimations have been made of the amounts of phosphate retained by hydrogen kaolinite and hydrogen bentonites prepared respectively from a sample of kaolin from Singbhum and a sample of bentonite from Kashmir on the addition of varying amounts of phosphoric acid to them. The effects of (i) particle size; (ii) equilibrium pH; and (iii) free inorganic oxide on phosphate fixation have also been studied.

The hydrogen kaolinite and the hydrogen bentonite used in the present work have quite an appreciable phosphate fixing capacity. The amounts of phosphate retained have been found to depend on (i) the concentration of phosphate in solution; (ii) the equilibrium pH and (iii) the time of interaction. In the acid region, hydrogen kaolinite adsorbs more phosphate than hydrogen bentonite. With an increase in the equilibrium pH the difference in the amounts of phosphate adsorbed by the two minerals decreases until in the region of pH 7.0 to 9.0 hydrogen bentonite fixes more phosphate than hydrogen kaolinite. At a concentration of 0.002N H_3PO_4 , the coarsest fraction (2.0 μ to 0.16 μ) of hydrogen bentonite retains as much phosphate as the finest one (0.05 μ). At higher concentrations (e.g. 0.11N) of added phosphoric acid phosphate fixation is greatly influenced by particle size; the amount adsorbed by the coarsest fraction being about one-fourth of that adsorbed by the finest one. On treating the system according to the method of Troug *et al* which is considered to remove only the free inorganic oxides the coarsest fraction loses its phosphate fixing capacity. The base exchange capacity of this fraction however, remains practically unaltered after such treatment. The phosphate fixing capacity of the finest fraction is reduced to one half of its original value and its b.e.c. also decreases on treatment according to Troug's method.

2. Displacement of H^+ , Al^{+++} and Fe^{+++} ions from clay minerals on repeated neutral salt treatment and desaturations*.

J. N. MUKHERJEE, B. CHATTERJEE and A. ROY, Calcutta.

Estimations have been made of the amounts of H^+ , Al^{+++} and Fe^{+++} ions displaced from the following systems on repeated leaching with $BaCl_2$ till these quantities could not be detected in the salt extract:

- the coarsest (2.0 μ to 0.16 μ) and the finest (<0.05 μ) subfractions, K-B, and K-H, respectively, prepared from the entire clay fraction of a deposit of bentonite from Kashmir.
- the hydrogen kaolinite, H-K, prepared from a deposit of kaolin from Singbhum.
- the hydrogen pyrophyllite, H-P, prepared from a natural deposit of pyrophyllite.

* The work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

The Ba-clay thus obtained has been desaturated into H-clay by leaching with 0.02N HCl followed by washing with distilled water and again treated with N-BaCl₂ as described above. This sequence of desaturation and leaching with BaCl₂ has been repeated four times with K-B₂ and K-B₁, five times with H-P and eight times with H-K. The base exchange capacities have also been determined for K-B₂, K-B₁ and H-P before and after the series of leachings and desaturations.

The amount of H⁺ ions displaced from K-B₂ decreases with successive desaturations but that displaced from K-B₁ increases up to the third desaturation and then decreases. With H-K the quantity of displaced H⁺ ions remains practically constant up to the fifth desaturation and then decreases slightly tending to a constant value. In the case of H-P this amount decreases regularly with successive desaturations tending to a constant value. With K-B₂ and K-B₁ the total amount of displaced Al⁺⁺⁺ ions decreases with successive desaturations. This amount decreases to almost negligible value in the case of H-K and a H-P. The amounts of Al⁺⁺⁺ ions displaced from the above systems are in the order : of K-B₂ < K-B₁ < H-K = H-P. Appreciable amounts of Fe⁺⁺⁺ ions are displaced from K-B₂ and K-B₁, that from K-B₁ (13.9 m.e. per 100 gms.) being many times greater than that displaced from K-B₂ (3.3, m.e. per 100 gms.). Fe⁺⁺⁺ ion could not be detected in the BaCl₂ leachate of H-K and H-P. The ratio of displaced H⁺ ions to Al⁺⁺⁺ and Fe⁺⁺⁺ ions increases with successive desaturations with K-B₂, K-B₁ and H-P. With H-K it shows irregular variations but on the whole increases. A marked reduction in the base exchange capacity (b.e.c.) is observed after repeated salt treatment and desaturations with K-B₂ and H-P. The b. e. c. of K-B₁ remains practically unaltered under similar conditions. Appreciable amounts of dissolved silicic acid are present in the BaCl₂ leachates with K-B₂ and H-P. The salt extract of H-K does not seem to contain any dissolved silicic acid.

3. On the nature of laterite and red soils of India.

S. P. RAYCHAUDHURI, Delhi.

The examination of the morphological features of a number of profiles of red and lateritic soils of India suggests that these and soils may be broadly divided into three groups : (1) Rocky laterites, (2) *Murrum* laterites and (3) Red loams. Intermediate formations and sub-groups are also noticed. The rocky laterites are characterised by honey-combed rocks and the *murrum laterites* by pisolitic iron concretionary nodules in their morphological features, whilst the red loam is sandy and comparatively immature. The nature of these three groups of red soils and their sub-groups has been studied.

4. Influence of fertilisers on the evolution of carbon dioxide in Matsi and Dorsa soils under aerobic and water-logged conditions.

S. L. VISHNOI, Raipur.

Evolution of carbon dioxide under aerobic and water-logged conditions from the two main rice soils of Chhattisgarh, namely, *mutasi* (sandy loam) and *dorsa* (clayey loam), when treated with and without nitrogenous and phosphatic fertilizers as cattle dung, *karanj* cake, ammonium sulphate and superphosphate, both singly and in combinations, was recorded daily for 12 days, with the object of assessing the fertility value of the soils.

In all cases the evolution of carbon dioxide is more under aerobic than under water-logged conditions, the heavier soil *dorsa* producing more carbon dioxide than the lighter soil *mutasi*. The production of carbon dioxide from these soils increases correspondingly with the addition of doses of manures.

Cattle dung and *Karanj* cake enhance the production of carbon dioxide from both the soils, while ammonium sulphate has a depressing effect, both under aerobic and water-logged conditions.

Application of phosphatic manures exerts an inhibiting influence upon the evolution of carbon dioxide, the depressing effect being retained even in combination with cattle dung and *karanj* cake.

Though superphosphate and ammonium sulphate depress the production of carbon dioxide when applied separately, they enhance it when applied in combination.

5. Assessment of the fertility of Punjab soils.

DALIP SINGH and INDRA SAIN, Lyallpur.

Four types of soils with known grades of fertility were examined by chemical methods and Mitscherlich and Neubauer pot tests, in order to find out their comparative nutrient status and therefore their manurial requirements. Both, chemical analysis

and Neubauer pot tests with Sudan grass and wheat, indicated similar degrees of deficiency of all the three chief manurial ingredients in three of the soils according to their grade of fertility, while the 4th high grade soil appeared to lack only in potash. Mitscherlich pot tests with wheat and sorghum as test crops, however, showed that these soils were deficient in nitrogen and phosphorus while potash appeared to be present in adequate amounts in all.

Replicated field trials were carried out on loam and light soils, to confirm these findings using economic doses of nitrogen, phosphate and potash manures alone and in combinations on wheat. The results closely corroborated the finding of Mitscherlich pot test. Addition of potash to nitrogen and phosphorus resulted in an increase of yield which was economical only in case of loam soil.

The economics of the application of these manures have been worked out and it has been found that at the current rates of fertilizers and produce, the application of 200 lbs ammonium sulphate and 100 lbs superphosphate resulted in a net gain of Rs. 70/- per acre on an average, both in the case of loam and light sandy soil. Further trials are in progress.

6. Exchangeable bases in some Travancore Rice Soils.

A. P. A. BRITO-MUTUNAYAGAM and P. S. NARAYANAN NAMBIAR,
Trivandrum.

A study was made of the exchangeable bases in twelve typical rice soils of Travancore representing six important types. The data showed that in most of the soils examined calcium is the principal replaceable base followed by magnesium, sodium, and potassium respectively. Soils subject to flooding with sea water contained appreciable amounts of exchangeable magnesium, sometimes far in excess of the adsorbed calcium. It is obvious that the magnesium ions in sea water have entered the soil colloid complex at the expense of the calcium ions by replacement.

A fairly good correlation was found to exist between the total amounts of replaceable base and soil texture. A general relationship was also observed between the pH and the exchangeable calcium in soils of the same type. Owing to the limited number of soils studied, these conclusions may be considered for the present as tentative.

These base exchange studies are being extended with a view to determining more fully the influence of the various exchangeable cations, including hydrogen, on the fertility of the rice soils of Travancore.

7. Study of alkaline patches at Pusa.

S. V. DESAI and ABHISWAR SEN, New Delhi.

This is a preliminary report of the studies of alkaline patches at Pusa. Alkaline patches in two fields are studied. These patches appear only in winter and disappear in the rainy season. The distribution of the soluble salts along the profile of the alkaline patches is compared with that of the adjoining normal soil. Striking changes in the mechanical composition of the soils are noticed in the alkaline patches.

8. The manganese status of Mysore soils.

H. G. GOPALA RAO and B. T. NARAYANAN, Bangalore.

Preliminary analysis of typical red and black soils of Mysore from four varied soil climatic zones indicates a wide variation in both total and replaceable manganese the former ranging from 200 to 2400 parts per million and the latter from 2 to 120 parts per million. The replaceable manganese does not seem to be a factor of the total manganese but appears to be influenced by the total soil organic matter and soil reaction; the higher the former and the more acid the soil the greater is its availability. The influence of the total and available manganese on crop yields in relation to their soil climatic complexes is discussed.

9. Potash status of Nanjanad soils.

N. S. MONEY, Trivandrum.

A preliminary investigation of the potash status of the Nanjanad soils has been taken up. A number of soils were analysed for potash content. Most of the soils showed a very low potash content and a small number showed high total potash content but were low in easily available potash. The conclusions drawn are tentative.

The work is being continued to confirm these results,

10. Studies on soil systematics : (i) black soils of Madras Deccan

H. SHIVA RAU and S. KASINATHA, Coimbatore.

Black soils of Madras Deccan are like similar occurrences of the Tropics, considered to be tropical analogues of the Tshernozems. Like the latter, they show the effects of restricted water movement in that the profile gets matured even when the mono- and divalent bases are but partially removed and illuviated ; the silica and sesquioxides being but little mobilised. The Black soils of the tropics however differ characteristically from the Tshernozem in having a low organic matter content and in the absence of "Crotoninas". For these and other minor reasons, the tropical black soils to which the Indian "Regur" belongs, have been assigned a distinctive position in tentative systems of soil classification.

Closer examination of the Black Soils of the Madras Deccan reveals the presence of at least two important sub-groups, which are characterised by different morphological features. On the basis of such differences the two sub-groups may be assigned to "Salty alkali" and "Brown Steppes" soils.

The available evidence bearing on the above classification is discussed ; the probable causes of their formation and their reaction to artificial changes in the normal water-regime of the area is indicated.

11. Studies on the nature and extent of decomposition of organic materials of varying c-n ratios in black soil.

H. SHIVA RAU and RAJAGOPALA AYYANGAR, Coimbatore.

With a view to find out ways and means for preserving and enriching the organic matter and nitrogen in the black soil of the tungabhadra Project area to be brought under irrigation and intensive cultivation, fundamental studies were started in pots with soil from Siruguppa, to follow the nature and extent of decomposition at definite intervals of selected plant materials e.g., sunnhemp and paddy straw besides other organic manures viz. cattle manure and groundnut cake, with varying C-N ratios. The experiment was conducted both in presence and absence of ammonium sulphate at 50% moisture holding capacity of the soil.

The analytical data collected for the different periods of decomposition 7, 15, 30 and 60 days, lead to the following conclusions.

1. Organic decreases appreciably (40 to 70%) in all the samples, the maximum loss being with groundnut cake (70% and over).

2. Considerable loss of alcohol-benzene solubles is noticed of in all the samples (50 to 90%) with a maximum of more than 80 % for groundnut cake and 30 to 50% for the other treatments.

3. There is uniform and all-round reduction of lignins and protein values in the treated soils.

4. Very little hemicelluloses and celluloses are present in the samples, except in the case of green manure (Sunn hemp) and paddy straw-treated soils.

5. The total nitrogen in the various samples has not been affected to the same extent as the organic matter and the losses in the several cases were within the limits 17 to 40% depending on the nature of treatment.

6. Major portions of nitrogen were present in 80% H_2SO_4 extract and lignin fractions, the extent of these forms of Nitrogen not being high in the case of groundnut cake which has shown a decrease up to 55% in the acid extract.

7. Loss of 20% HCl soluble nitrogen (8 to 60%) is noticed in the different samples depending on the nature of the material subjected to decomposition, the extent of loss being greatest in groundnut cake.

8. Increase of water soluble nitrogen is noticed in groundnut cake treated soil as against considerable loss of the same seen in the other treatments.

These results in short indicate the possibility of enriching the organic matter and nitrogen in the black soil under irrigated conditions by a judicious incorporation of oil cakes and straw or green loaf so as to maintain the "lignin-cellulose", and "protein", preferably in the ratio of 3 : 1 or 4 : 1.

Observations made on the influence of decomposing organic materials on the total exchangeable bases in black soil show a very good increase in the total bases at the end of two months after the addition of organic materials, the order of importance in this respect being cattle manure, straw, green manure, and ground-nut cake.

12. Note on soil colour

J. C. BHATIA and A. N. PURI, Lahore.

Experiments were conducted to study the effect of varying amounts of iron on the colour of the silicates. The results showed that colloidal Fe_2O_3 is not absorbed by

silica and any colouration mechanically imparted is easily removed by dilute acid treatment. Colour in soil must therefore be taken as due to the gradual bleaching of silicates by CO_2 water during natural process of weathering.

Dairy Chemistry and Animal Nutrition

13. A study of sheep and goat milk.

K. M. MEHTA, Jodhpur.

An examination of the composition of Sheep and Goat milk in different parts of Jodhpur state reveals wide variations in composition. The fat p.c. and total solids p.c. vary from 4.7-6.3 and from 12.0-15.0 in the case of Sheep milk and from 3.0-4.3 and from 10.0-11.5 in the case of Goat milk. The results have substantiated the facts that the main factors for variations are the seasonal changes and regional differences. An important fact has also been borne out that Goat milk can be evaluated as nutritive as Cow's milk, and that greater attention should be paid to Goat improvement.

14. Physical and chemical constants of goat and sheep ghee.

K. M. MEHTA, Jodhpur.

The physical and chemical constants of Goat and Sheep Ghee are affected by seasonal and regional factors. The butyro-refractometer values range from 41.5-44.0 and from 42.5-43.4, Reichert-Meissl values from 19.0-26.0 and 265.0-28.0, Polenske values from 3.0-6.7 and 2.8-3.6, Saponification values from 226.0-235.0 and 229.0-234.0 and iodine values from 28.0-39.0 and 32.0-37.0 for Goat and Sheep Ghee respectively. The results clearly show that for regions like Jodhpur state the Ag. Mark specifications need modification as the production consists of a mixture of cow's, buffalo's, goat and sheep ghee.

15. Preservative effect of common salt on the development of acidity in stored ghee.

LAL CHAND DHARMANI and KARTAR SINGH LOHARA, Layallpur.

To study the preservative effect of common salt on the development of acidity in ghee during storage, 90 one lb samples of ghee with varying amounts of moisture (0.5% to 1.5%) in the form of water and butter milk (lassi) were stored in one lb airtight tins and small earthen pots, covered with earthen lids. Salt was added at the rate of 2.0% of the weight of ghee.

The rancid behaviour of ghee was judged by the development of an acrid taste, characteristic aroma and increase in the free fatty acids. The samples were tested periodically for fifteen months.

In case of air tight tins the increase in acid value was from 0.50 to 0.73 in fifteen months both in salted as well as in unsalted samples. There was no change in the smell and taste of ghee. Moisture up to 1.5% and salt at the rate of 2.0% had no effect on the keeping quality of ghee during storage. Good quality ghee can be stored safely in air tight tins up to 15 months. The presence of butter milk (0.25%) accelerates the development of acidity.

It is not advisable to store ghee in earthen pots as ghee oozes out of the pots during summer months and thus causes a considerable loss. Besides, the development of acidity is fairly rapid.

16. Effect of feeding green roughage on the quality of fat. Part I. Green feeding in the form of pasture grazing.

B. M. PATEL, Anand.

With a view to noting whether green feeding (pasture grazing) is capable of neutralising the effect of cotton seed feeding and of producing greater proportion of higher fatty acids in the butter fat secreted by the animal, this experiment was carried out.

Buffaloes during the three experimental feeding periods were given the following concentrates and roughages: (1) dairy mixture and grazing for the 1st month, (2) cotton seed and grazing in the next month and (3) in the last month cotton seed and dry *kadbi ad lib*. The samples of fat of each experimental period and of each individual animal were collected and analysed for their physical and chemical constants.

The results show that (1) dairy mixture feeding and grazing produce a normal butter-fat, (2) cotton seed feeding increases fatty acids in butter fat in spite of introducing green feed in the form of pasture grazing, (3) substituting dry fodder for grazing has little effect on the physical and chemical constants of the butter fat.

17. Effect of feeding green roughage on the quality of fat. Part II. (Green feeding in the form of different silages.

B. M. PATEL, Anand.

Feeding of the following different silages prepared by different methods and also of different grass-fodders have been carried out to mark their effect on the quality of butter fat :

(1) Silage of *Zinzavo* grass (*Andropogon annulatus*) prepared by three different methods (a) lightly packed, (b) heavily packed, (c) molassed silage.

(2) Silage of different fodder and grasses, (a) Maize (*Zea Mays*), (b) *Varelu* grass (*Ischaemum rugosum*), an annual grass.

(3) Mixed grass silage.

The effect of feeding above silages was compared with hay feeding on 18 Kankrej cows and the results indicate that (1) no significant effect takes place on the physical and chemical chemical constants of butter fat and (2) the feeding of *Varelu* silage slightly alters the quality of fat.

18. Digestible energy of roughages and concentrates.

LAL CHAND DHARMANI, SHEER SINGH MANGAT and KARTAR SINGH LOHARA, Lyallpur.

Determinations of gross calorific value of feeds given to experimental animals and the dung voided, were carried out with the fuel calorimeter. The results show that the figures for the digestible energy value of feeds, determined by the calorimeter, agree well with those obtained by calculations from the analytical data of different constituents. It is possible to use the combustion method for the routine determination of the digestible energy of feeds.

The estimations of fat, fibre and carbohydrates are eliminated with the new method. Estimations of dry matter only in the feeds and dung followed by a determination of their calorific values, is enough to find out the digestible energy of the feed. The saving in time and material by the calorimetric method is ample justification for its employment. It is suggested that nutritive value of feeds should be expressed in terms of digestible energy and digestible protein instead of total digestible nutrients and digestible protein. Work is in progress.

19. The mineral composition of some natural fodder grasses of Travancore and its bearing on animal nutrition.

A. P. A. BRITO-MITUNAYAGAM and M. C. ABRAHAM, Trivandrum.

Travancore cattle are small, undeveloped, and economically very unproductive. This is by no means surprising as the vast majority of our village cattle are uncared for and subsist entirely on natural grazing. In view of the supreme importance of minerals in animal nutrition, a study was made of the mineral contents of some natural pasture grasses collected from different parts of the State.

The results reveal that the natural fodder grasses of Travancore are extremely deficient in both lime and phosphorus, the two most essential minerals. The data show that they generally resemble in composition the 'British poor pasture' not eaten by cattle in the British Isles. It is also worthy of note that rice straw which is the staple food of cattle in many parts of Travancore is highly deficient in all essential minerals.

These findings are of considerable importance and appear to largely account for the deteriorated condition of our cattle both as regards physical development and capacity for work and milk production. The inclusion of some concentrates and a mineral supplement in the ration is strongly urged to ensure a well-balanced diet and thereby help to eventually build up a more economic and better class of animal.

20. Studies on the possible uses of Agricultural and Industrial By-products; Silk worm residues as feed for livestock and poultry and as manure.

K. LAKSHMINARAYANA BHATTA and B. T. NARAYANAN, Bangalore,

The body tissue of silk worms which forms a waste product of the sericulture industry has been found on analysis to contain over 20 percent of fat rich in vitamin A, and 50 percent of protein, of which nearly 15 percent is water soluble. It compares favourably in food value with standard feeding stuffs like groundnut oil cake and cotton seed meal. The fat can be converted by treatment with activated charcoal, to a cream colour faintly

odorous soft solid, not unlike ghee in appearance. The fat free residue has a nitrogen content of over 8 percent being of the same order as groundnut cake now extensively used as manure.

There seems to be a good field for the utilization of this waste product as a concentrate feed for poultry and livestock; for the conversion of the fat to margarine or as a base for soaps and the fat free material as manure.

21. Studies on the souring of milk in the 'Desi' (curd) of preparation of butter and ghee.

M. R. SRINIVASAN and B. N. BANERJEE, Bangalore.

The process has been studied under the heads (1) processing of milk, (2) seed culture, (3) souring or fermentation.

Processing milk by boiling for 10 minutes or evaporating to reduced volume by 5% has been found to be perfectly satisfactory. It ensures maximum of germ destruction with the minimum of undesirable flavour in milk. The quality of the curd, butter and ghee as also the retention of the vitamin A and carotene in ghee are quite good.

Seed curd obtained by mixed flora is better than pure cultures of *lacto-bacillus acidophilus*. An acidity in the seed curd from 0.8 to 1.0% (lactic) is quite satisfactory. The criterion of good seed curd is to use sweet smelling curd of fine aroma with a firm and uniform texture. A measure of the lactose of the seed and correlation of the same with the acidity will give an indication as to the presence of non-lactic organisms and moulds. Milk used for preparing seed culture should be sterilised or vigorously boiled to keep down undesirable microflora.

Changes taking place during souring are (1) pH of milk goes down from 6.9—6.5 to 4.4 after which it becomes stationary. (2) Titrable acidity increases with time and after reaching a value of 1.2 (lactic) at temperatures 25–40°C. slows down. (3) The amount of lactose used up is almost equivalent to the acidity developed until the acidity is 1%. At later stages of fermentation, usually after 24 hours at 25–40°C. more lactose is used up without any proportionate increase in titrable acidity.

22. Acidity of curd and the churning process

M. R. SRINIVASAN and B. N. BANERJEE, Bangalore.

The influence of acidity on the churning as practised in the 'Desi' method was investigated by (i) churning milk cooled to 10° and 20°C. (ii) churning milk brought to 0.4% (lactic) acidity by the addition of lactic, citric, tartaric acids and high acid butter. milk at 22 to 25°C. (iii) churning milk after increasing the acidity to 0.4% by citric acid and souring of acidified milk by the addition of starter to 0.7% acidity and (iv) churning of curd after ripening with starter to 0.7% and 1.1%. It was observed that acidity helped in stopping foaming during churning. Acidity in milk as brought about (iii) and (iv) to 0.7% helped recovery of 90% of butterfat. Artificial increase in acidity led to sudden coagulation of the curd resulting in fat losses upto 30%. The effect of dilution of curd during churning under the different conditions and the fat losses in butter milk have been recorded.

Agricultural Chemistry

23. Suggested simplification of mechanical analysis of soils.

S. V. DESAI and ABHISWAR SEN, New Delhi.

Fine fraction of the soil which consists of silt and clay is responsible for many of the characteristic properties of the soil. It is suggested that the ratio of coarse to fine fraction of a soil be taken as an index of soil texture. A quick method of determining the coarse or the sand fraction of the soil is described.

24. Calculation of starch from dry matter in Potato.

ABISWAR SEN, New Delhi.

Several rough and ready methods of estimation of starch based on specific gravity of potato tubers are in vogue. One such is to estimate the moisture content and therefrom calculate the dry matter. Dry matter—5.75 is generally taken to be the amount of starch. The author has estimated starch in a large number of potato varieties, grown in India. He finds that dry matter—5.75 gives too high starch values. Dry matter—5.39 gives much closer values, the standard deviation by such being $\pm 2.14\%$.

25. Comparative study of some rapid chemical methods in Indian soils with the usual official methods.

B. VISWANATH and K. M. MEHTA, Jodhpur.

Rapid chemical methods of analysing soils suggested by Hawaiian Planter's Association are applied to Indian Soils for nitrogen and phosphate estimation. The findings clearly show that with slight modification the rapid chemical methods can be made applicable for Indian soils. The results obtained by rapid chemical methods are in good agreement with those of A. O. A. C. Methods. Estimation of ammoniacal and nitrate nitrogen by the said rapid chemical methods show wide variations.

26. Comparative studies on the estimation of decolorizing activity of 'Activated' carbon.

M. R. CHANDRASEKHARA and B. T. NARAYANAN, Bangalore.

In an attempt to standardize a decolorizing activated Carbon prepared locally for use on cane syrup, three standard methods of estimation by (1) the iodine number (2) the permanganate number and (3) the molasses number were examined. The last named method was found to be the most reliable index of the activity of the carbon under test.

27. Rancidity of roast coffee in relation to staling.

M. R. CHANDRASEKHARA and B. T. NARAYANAN, Bangalore.

It is commonly observed that roast ground coffee develops staleness rapidly on exposure to air whereas it keeps fresh for long periods when air is excluded. Peroxidase estimations of ether extracts of fresh roast coffee, 'stale' coffee and vacuum packed coffee showed that there was little or no difference in the respective peroxidase values indicating that the fat 'in situ' under any of these conditions had not gone rancid. On the other hand the extracted 'free' fat on exposure and keeping becomes rancid rapidly. Methods of storage in relation to staleness and rancidity are discussed.

Agricultural Botany

28. Nitrogen content and yield of sugarcane.

N. L. DUTT and K. B. GOPALA AYYAR, Coimbatore.

Preliminary studies were taken up at the Imperial Sugarcane Breeding Station Coimbatore, to ascertain under Coimbatore conditions the applicability to sugarcane of the Law of Inverse Relation of nitrogen content and potential yielding capacity of plant species. According to this law the first essential characteristic of a high yielding variety would appear to be that it should have a low percentage content of nitrogen.

In the first series 21 sugarcane varieties comprising the more famous Co. canes and their parents were considered with reference to known varietal yields and nitrogen content of leaves and stalks. In the case of nitrogen content of leaves there were many exceptions to the law. In regard to the nitrogen in the stalks, there appeared to be slightly better conformity with the law, though there were still many exceptions.

In the second test the actual yields in the plots were taken into account and the nitrogen content of not only the stalks and leaves, but also of the whole cane were considered. The data were obtained separately for 'Wet land' and 'Garden land' type of soils. The results did not conform to the law; indeed in most cases they were quite contrary to it.

These studies have tended to show that the Willcox law of Inverse Relation of nitrogen and yielding ability may not be strictly applicable to sugarcane at least under Coimbatore conditions. This it is felt may in part be due to the complex nature of sugarcane varieties whose parents are derived from several separate species and genera.

29. X-ray treatment of cotton seed.

K. RAMIAH and BHOLA NATH, Indore.

Among the tools available to the breeder to produce mutations in crop plants on a large scale, X-rays should be considered most important. The general experience of breeders in India with X-ray treatment in rice, wheat, *bajri*, sugarcane, cotton, jute, etc., has been that while most of the mutations have proved only of scientific value in advancing the genetical knowledge of the particular crop concerned, they have not proved

of any economic value. Among the exceptions to the above general finding may be mentioned the bud mutation from sugarcane obtained in Bangalore and a mutation in rice obtained by the senior author of this paper at Coimbatore, both of which have proved valuable and been established as new improved varieties.

Dry seeds of 11 established cotton varieties, 9 *desi* (*G. arboreum*) and 2 American (*G. hirsutum*) were exposed to X-rays before sowing for 10 minutes and 20 minutes under K. V. P. 65 (Ma 10) with a target distance of 15 cms. The X_2 s were grown in single lines with the control by the side and the X_2 , X_3 onwards in regular replicated trials. Apart from the general poorer viability of the treated seeds in X_1 , the only significant difference obtained in X_2 was with regard to higher node number in one of the *desi* varieties and with regard to ginning percentage and length of fibre in one of the American varieties, M. U. 4. Since higher node number is not a useful character nothing further was done to this. With regard to the American variety, M. U. 4, the isolated progenies with a higher ginning percentage and longer fibre and the bulks developed from them have been grown up to X_3 and have consistently proved better than the control in these characters with the result that a new improved variety over M. U. 4 has been established.

To make sure that the new variety has not come from an extreme natural variation in the original material but is a result of X-ray treatment only, the experiment was repeated with selfed seed of a single plant of the same variety, M. U. 4, and the work that has gone up to X_3 entirely confirms the original results, namely, that strains with a higher ginning percentage and longer fibre can be obtained from X-rayed material.

30. Evolution of high-yielding hybrid 'bhendi' (*Hibiscus esculentus*).

C. VIJAYARAGHAVAN and U. ACHUTHA WARIAR, Coimbatore.

Studies were made at Coimbatore on this vegetable with the object of isolating high-yielding hybrid plants. Flowers in *Bhendi* are solitary and axillary. The corolla begins to emerge by 10 P.M. and opens out by 8 A.M. on the next morning. Artificial pollination is comparatively easy in this plant. Flowers intended for crossing should be emasculated the previous evening. The calyx and corolla are cut open and anthers scissored off. The flowers are kept covered overnight and the next morning pollen is brought from the desired male parent and dusted on to the stigma. This method gives about 80% success. Fruits take about twelve days to attain their maximum size and 30 days to ripen. For use as a vegetable the fruits have to be picked by the eighth day. Plants continue to bear for a longer period when the green fruits are picked regularly. Twelve cultures were found to be promising in yield tests. One hundred and forty seven crosses were made between different parents for earliness, fruit colour, shape and absence of spines. Distinct evidence of hybrid vigour was observed in the number, size and weight of fruits.

31. Storage and fertilising capacity of sugarcane pollen.

N. I. DUTT and M. VIJAYASARADHY, Coimbatore.

Sugarcane pollen has been found to remain viable only for a few hours under ordinary atmospheric conditions. In the series of experiments done to study the effect of different temperatures (0° to 25°C) and relative humidities (50% to 100%) singly and conjointly on the viability of cane pollen (*S. spontaneum* Tank and Kansar), it was found that a temperature of $11^\circ \pm 1.8^\circ\text{C}$ and $87\% \pm 3\%$ R.H. are ideal for storage of cane pollen.

The pollen stored in the medium of CO_2 , in N_2 , in vacuum, in gelatine capsules and under CaCl_2 and soda lime was observed to lose viability soon and show a tendency to crack. On the other hand the pollen stored in vacuum flask under optimum conditions shows maximum viability and good powdery condition. It was further observed that (1) the pollen of different cane varieties exhibits different periods of viability, and (2) the viability period and the germination capacity of pollen gradually decline with storage. The pollens of *S. spontaneum* Tank, Boria, Lalri, Co. 301, Co. 285 are able to retain viability for 60 days.

Though stored sugarcane pollen has been found to retain its viability for as long as a period as 60 days, actual fertility tests conducted at Coimbatore have shown that the fertilising capacity of sugarcane pollen lasts only up to 3 days from the time of collection. Transporting of pollen by aeroplane seems to be the only satisfactory method of transporting cane pollen for long distances for hybridization work.

32. Studies in fodder grasses. 1. Drought resistance in relation to structure.

S. N. CHANDRASEKARA AYYAR, S. V. PARTHASARATHY
and D. DANIEL SUNDARARAJ, Coimbatore.

Of the twelve species of perennial fodder grasses under study at Coimbatore, the structural adaptations of three grasses viz., *Panicum antidotale*, Retz., *Oxydodon plectos-*

tachyum, Pilger., and *Iseilema laxum*, Hack., have been studied. These three are in the order mentioned above in regard to their degree of drought resistance.

Root system, and structure of root, stem and leaf have been examined to find out the adaptations for drought resistance. While *P. antidotale*, Retz., is ideally adapted in all these plant organs studied, *C. plectostachyum*, Pilger., is intermediate due to (a) chlorenchyma in root, (b) the cells of the stem being thin walled, (c) the leaf being less efficient in the utilisation of light though it is adapted for rolling to minimise loss of moisture through transpiration. In the case of *I. laxum*, Hack., though the stem and leaf appear to be structurally fairly well adapted for resistance, the root system is shallow and also structurally ill adapted for efficient functioning during drought.

33. Pith in cane and cane seedlings.

N. L. DUTT, M. K. KRISHNASWAMI and SYED ABBAS HUSSAINY,
Coimbatore.

Sugarcane varieties differ in the extent of pith in the stem. In view of the economic nature of this character of pith, the present study was undertaken with a view to finding out the nature of inheritance of pith in sugarcane seedlings, as such a study would enable the selection of suitable parents and combinations for the breeding of seedlings with a solid core. In this paper the term 'pith' is used in the restricted sense of dead parenchymatous cells which often result in a hollow cavity in the centre of the stem.

The parent Co. canes and the subsequent Co. canes have been studied for this character. The nature of inheritance has been examined in five varieties, 4 prominent Co. canes, Co.213, Co.281, Co.349 and Co.508 and the wellknown Java variety, P.O. J.2878. Out of these the two pithy types, Co.349 and P.O.J.2878 pass on their pithy character to the progeny and so if these are used as parents, considerable amount of pith is to be expected in the offspring.

The varieties Co.213, Co.281, and Co.508 which possess a solid core transmit this character to their seedlings as also another Co. cane, Co.301 which gives non-pithy seedlings even with such a badly pithy type as P.O.J.2878. Hence for obtaining non-pithy types the above mentioned varieties could be used with advantage especially Co.213 and Co.301.

The desirable combinations for the production of non-pithy seedlings are: (1) Co. 213 \times Co.244, (2) Co.213 \times Co.301 and (3) P. O. J. 2878 \times Co.301.

34. A study of the suitability of waters for irrigation and their improvement.

DALIP SINGH and DEY RAJ CHAWLA, Lyallpur.

Experiments were made to study the effect of varying amounts of salts in irrigation waters on two types of soils and the influence of the addition of calcium and nitrate ions on the quality of irrigation waters as affecting the growth as well as yield of wheat crop grown under controlled conditions. The results have shown that the light soil produced higher number of tillers, attained better heights and yielded more of straw than the heavy one with waters containing high amount of bicarbonates and other saline salts up to a limit of 200 total salts per 100,000 parts. The saline waters effected an increase in heights and yield of straw and grain as compared with canal water though there were no significant differences due to different concentration of salts. The addition of nitrates to the canal water increased the number of tillers and yield of grain in both the straw in the light soil only. In addition, the saline waters increased the yield of both soils and of grain and straw in the light soil but had no effect on yields in heavy one. Salts when added to canal water increased the height of plants and the yield of grain and The calcium straw in both the soils though their addition to saline waters had a beneficial effect in the light soil but decreased the yields in the heavy one, especially when waters containing total salts 150 per 100,000 parts and above were applied. It was observed that calcium salts when allowed to react with waters containing carbonates and high amounts of sodium bicarbonates, counteracted the toxic effect of these salts and resulted in increased yields.

35. The effect of irrigation on the quality and the mineral uptake of sugarcane.

JIWAN DASS CHOPELA, Lyallpur.

These irrigation experiments were carried out at Rosalwala Agricultural station in the Punjab. It was observed that the uptake of mineral matter, the yield of cane and the juice percentage increased with the increase in the number of irrigation, when the intensity of each irrigation was the same. It was further observed that to obtain high yield, more irrigations are to be given during the maximum period of growth i.e.

during the month of July and August. Both the quality and yield in sugarcane crop deteriorated in heavy irrigations in the early stages of growth.

Agronomy

36. Recent experiments on manuring.

ABHISWAR SEN, New Delhi.

Superiority of organic manures over inorganic fertilisers is questioned. It has been found in England as well as in India that unit for unit of nitrogen farm yard manure is only half as efficient as ammonium sulphate.

Organic manures are bulky and most of them consist largely of water and sand. Considering the market prices they are many times costlier than the inorganic fertilisers.

Some recent experiments in Europe have proved that crops raised with mineral manures are superior in quality than those raised with organic manures.

37. Raising crops without manure.

ABHISWAR SEN, New Delhi.

In India, rainfall and the fertility of a soil are positively correlated. It has been found that crop yields can be significantly increased by increasing the water supply. There is evidence to show that supply of plant nutrients like nitrogen and phosphoric acid is increased by increasing rainfall. This need not be done by actual supply of inorganic or organic manures.

38. A new source of manure from surplus ammunition for the Indian farmer.

S.V. DESAI and N. D. VYAS, New Delhi.

The most important explosive material manufactured in India during the period of war was ammonium nitrate. When mixed with T. N. T. in certain proportions it becomes highly effective. Anticipating that a huge quantity of this highly concentrated nitrogenous product will be available for a better humanitarian task we decided to examine its use for manurial purposes. We, therefore, obtained 4 kinds of materials for use from the Ordnance Department, one was pure nitrate and the other three contained 1%, 2% and 3% T.N.T.

Experiments under field conditions were carried out with the above materials according to the modern experimental technique and pot-culture experiments were conducted with ammonium nitrate alone to see its effect on the utilization of indigenous phosphates like bone-meal and rock phosphate.

The results obtained are summarised below and The manures were applied to supply 40 lbs. nitrogen per acre i.e. approximately 1 cwt. of ammonium nitrate per acre :—

1. Ammonium nitrate is an excellent manure both for maize and wheat. It increased the yield of wheat by 103% and that of maize by 48.6% over the respective controls. The increases were statistically significant.

2. The presence of T.N.T. to the extent of 3% had no harmful effect on any of the crops under experiment. In terms of yield in mds. per acre of wheat the results stood as follows :

Control	14.4 mds. per acre
Ammonium nitrate	29.2 " "
" " 1% T.N.T.	26.2 " "
" " 2% "	26.8 " "
" " 3% "	29.1 " "

When combined with indigenous phosphates like bonemeal or rock phosphate efficiency of ammonium nitrate as well as that of phosphatic manures was increased. In pot culture experiments where ammonium nitrate increased the yield of wheat over the control by 89.4%, a mixture of ammonium nitrate and bonemeal increased it by 150.2%. The corresponding increase with ammonium nitrate and rock phosphate came to 136.5%.

39. The effect of nitrogenous manures on the quality of sugarcane.

JIWAN DAS CHOPRA and ATAM SINGH, Lyallpur.

From the results of manurial trials carried out at Jullundur and Lyallpur during the year 1944-45, it was observed that nitrogenous manures especially above 150 lbs of nitrogen per acre had a marked deleterious effect on the quality of the sugarcane juice result-

ing in low sucrose total solids and purity coefficient, though the yield increased to considerable extent. There was an increase in mineral matter in sugarcane juice by the application of cakes and farmyard manure.

40. Place effect on cotton.

K. RAMIAH and D. GANESAN, Indore.

Jarilla (*G. arboreum* var *bengalense*) is a new variety of cotton developed at the Cotton Station, Jalgaon, Bombay, some years back as suitable for the Khandesh tract. Because of its superiority over other *Omras* in fibre quality combined with a higher ginning percentage, the variety has spread very widely in several tracts outside Bombay as in Hyderabad, Berar and Central India replacing the local *Omras*. It has now been grown for some years at Akola (Berar) and Indore (Central India). Mainly to find out the large variations in ginning percentage observed in Jarills grown in different places, an experiment was undertaken to compare the different seed sources of Jarilla. Pure Jarilla seed obtained from Kalgaoon, Akola and Indore was grown in a replicated experiment on the same design at all the three places.

It is an established fact that the quality of the cotton fibre of the same variety of cotton can vary widely according to the place in which it is grown. It has now been established experimentally that the seed of the same variety can show large differences in such characters like seed viability, length of fibre, seed number per boll, weight of seed, ginning percentage and yield of kapas according to the source from which it was obtained. Jarilla seed grown in Indore is consistently poorer in germination, gives a higher yield of seed cotton, has a longer fibre, smaller seed number per boll, higher seed weight, and lower ginning percentage than the seed from the other two sources. The results are discussed from various points of view and it would appear to support the belief existing with the cultivators that seed from certain sources is always better.

41. Pretreatment with growth hormones and yields of millets.

C. VIJAYARAGHAVAN and T. R. NARAYANAN, Combatoro.

This paper presents an account of some preliminary studies made at Coimbatore on the effect of presoaking *Cumbu* (*Pennisetum typhoides*) and *Ragi* (*Eleusine coracana*) seeds in growth-hormones like indolyl-acetic acid and also in different dilutions of urine from pregnant cows. With *ragi*, presoaking the seed for 24 hours in 10% and 1% urine gave in one pot-culture experiment, increases of 78% and 86% in grain and 155% and 128% in straw weight and 20% more of grain alone in another field experiment. Flowering also was hastened by about a week. Presoaking in indolylacetic acid did not show any increase in yield. With *Cumbu*, soaking the seeds in undiluted cow's urine for 15 hours gave an increase in one field experiment, of 19% in grain weight alone. In another experiment, presoaking for 24 hours in 10% cow's urine gave an increase of 19% in straw weight and in a third experiment, plants from seeds soaked twice in 10% cow's urine for 15 hours each time showed an increase of 24% in grain yield over the control from untreated seed. In a similar experiment in pot-cultures, soaking twice in 10% cow's urine induced the plants to flower 5 days earlier with an increase of 48% in the total weight of dry matter. The study is being continued.

42. Cold storage of potatoes.

G. S. KULKARNI, Gwalior.

The paper contains the results of experiments on the preservation of tubers in Cold Storage for two seasons 1944-45 on 112 and 171 maunds of potatoes respectively. The temperature maintained was 35°F. and the tubers kept well without any rotting. The crop raised from these tubers was quite normal and the yields were also quite satisfactory.

43. Derris in Mysore: yield and quality in relation to soil climatic complex and age of bush.

K. LAKSHMINARAYANA BHATTA and B. T. NARAYANAN, Bangalore.

Derris elliptica was first introduced to Mysore in 1932 and has since been successfully cultivated at Bangalore, Balehonnur and Mandya, representing, the medium the heavy and the light rain fall zones respectively. The yield of root, (the main source of the principle insecticide) as well as its toxic constituents is influenced by soil and climatic conditions, dry conditions being favourable to high quality and wet conditions to high yield. The yield of dry root per bush at Balehonnur is on the average 200% higher

than that at Bangalore; while the rotenone content of root from Balehonnur is 4 to 5 per cent and that at Bangalore is as high as 8%.

The rotenone content of root is dependent also on the age of bush. Analyses of roots drawn from bushes of different ages from 15 to 27 months have shown that the rotenone as well as total ether extractives reach a maximum (8% of rotenone and 22% ether extractives) at about two years and decline progressively thereafter.

44. Studies on drought resistance in plants.

R. K. MISRA, Poona.

Mr. A. K. Mallik tested the drought resistance of two varieties of sugarcane by comparing their *transpiration* rates in a dry and a 'humid' environment respectively and comparing these rates with the *evaporation* rates in the two environments. Further work on similar lines for testing the drought resistance of two varieties of cotton, viz. CO.2 and CO.3 and two varieties of jowar, viz. Aispuri and Nagpur has been done by the present writer. The results indicate that the two cotton varieties have a certain amount of drought resistance while the jowar varieties have none.

45 The influence of the distance between the soil surface and the free water table on the root development of plants.

R. K. MISRA, Poona.

A new type of soil evaporimeter, designed at the Central Agricultural Meteorological Observatory, has been utilised for studying the root development of plants in relation to the depth of the water table. A preliminary experiment was conducted with jowar seedlings, grown in evaporimeters in which the water table was maintained at different depths. The results indicate that the root system grows deeper when the water table is farther away. When the water table is, however, too far away, no growth takes place. It has also been seen from the results that greater root development is associated with greater shoot development, and that the optimum plant growth occurs when the distance between the surface of the soil and the free water table is within a certain range.

46. Influence of rainfall on the yield per acre of Bajri.

H. R. ARKERI, Poona.

The influence of rainfall distribution on the yield of straw and grain of Bajri during a period of 14 years areas studied. It is found that

1. rainfall before sowing has little effect on yield of bajri.
2. heavy rainfall during the first 5 days after sowing, when the seeds are just beginning to germinate, depresses both the germination percentage and the final yield
3. three to nine inches of rainfall well-distributed during the growing season with alternate sunshine cause a good yield; rainfalls below 3" and above 9" affect the crop adversely.
4. heavy rainfalls during the flowering or the ripening period result in low yield, especially of grain.

47.. Crop-weather calendars and isochrones of (1) date of sowing, (2) date of flowering, (3) date of harvest and (4) the duration of the growing season.

L. A. RAMDAS, A. K. MALLIK and O. CHACKO, Poona.

Crop-Weather Calendars, "district-wise" and "crop-wise", were prepared for some important crops from replies to a questionnaire, received from Agricultural Departments of Provinces and Indian States. These calendars are intended for the guidance of weather forecasters in preparing the farmers' bulletins.

Isochrones of dates of sowing, flowering and harvest as well as the duration of the growing season for the wheat crop have been prepared from the Crop-Weather Calendars. These indicate that the dates of sowing, flowering and harvest as also the length of the growing season depend, to a marked extent, on temperature conditions. It seems, therefore, that wheat, unlike paddy, is more temperature controlled than water controlled. The maps also show that the replies to the questionnaire for different areas are consistent with respect to each other.

48. Soil surface temperatures in India

L. A. RAMDAS, Poona.

A scheme for the recording of soil surface temperatures at 18 selected stations in India was started in April 1943. The note gives a preliminary account of the first years' data. In clear and dry weather, temperatures as high as 75°C can be recorded by the soil surface, particularly in the black soil tracts of Central and Peninsular India. The distribution of soil surface temperature over India, particularly at noon is in accordance with the movements of the sun across the latitudes and the sequence of weather during the year. For example, the highest temperatures are recorded in the Southern parts of the country in winter and over North-west India in the monsoon months. In summer the Central and North-western parts record the highest temperatures.

Soil surface and air temperatures are highly correlated both at 07hrs and 12 hrs local time.

49. On radiation minimum temperatures.

A. NARAYANAN, Poona.

The minimum air temperatures recorded inside a standard Stevenson Screen do not indicate the minimum temperatures attained by material objects (like crops) exposed in the open in the air layers near the ground. Objects exposed fully to the sky undergo further cooling. The mean values of minimum temperatures recorded by thermometers exposed in the open in comparison with those of the Stevenson Screen and the corresponding depressions are discussed. It is shown that generally the highest values of minimum temperatures occur in June and the lowest in December. The highest depressions occur in April and their lowest values during the monsoon months. Further lower temperatures are attained by hygroscopic than by non-hygroscopic objects.

50. The effects of storage in Bombay on the quality of baled Indian cottons

C. NANJUNDAYYA and NAZIR AHMAD, Bombay.

The present investigation was undertaken with the object of assessing the extent of deterioration which takes place in the quality of some of the trade varieties of Indian cottons, when they are stored for two years in a commercial godown in Bombay. Six well-known trade varieties were selected and nine bales of each variety, were stacked in the godown side by side with the commercial bales. By adopting a special technique a representative sample of cotton was drawn from each bale without altering its size or shape; and it was re-pressed and stored again. The first samples were drawn in May, 1938 and the subsequent four drawings were made at intervals of six months between two consecutive drawings. Consequently, the second and the fourth drawings corresponded to the monsoon conditions of storage while the third and the fifth drawings corresponded to the dry periods of storage. These samples, drawn half-yearly, were tested for fibrestrength, lustre and moisture content while copper number of only a few samples was determined; and further, they were also spun into suitable counts, and the lea-strength and the ballistic work of rupture of the yarns were determined. The following main conclusions were drawn from the results obtained:—

1. These cottons generally suffered a loss in fibre strength on storage.
2. (a) Lustre showed a tendency to decrease continually from the commencement, which became more marked in the second year.
- (b) Different cottons responded differently to storage in respect of lustre.
3. (a) The moisture content of all cottons increased during the monsoon and decreased during the dry season, the changes being significant in all cases. However, at the end of two years the moisture content was higher than that at the end of one year which in turn was higher than that at the beginning.
- (b) Response of different cottons to moisture absorption and desorption when stored under the same atmospheric conditions was similar.
4. There was a considerable increase in Copper Number after the monsoon period, while the dry period recorded just the opposite effect. Thus, it appeared that there was a continual change in the non-cellulose substances, which would mostly affect the surface characteristics such as colour, lustre and clinging power.
5. The yarn strength (lea) increased significantly after the first monsoon period of storage and at the end of two years was nearly equal to or even greater than that at the commencement.
6. Although the trend of variation of ballistic work of rupture differed in some cottons from that of lea strength, the results of this test generally confirmed the main conclusion drawn from the lea strength.

51. Effect of fertilizers on fineness of cotton.

A. N. GULATI and NAZIR AHMAD, Bombay.

Fineness of fibres is usually expressed in terms of mean fibre weight per unit length, swollen hair diameter, wall thickness, the present investigation was undertaken to study the effect of fertilizers on these fibre properties, their inter-relationships and their bearing on fibre strength.

The material for this study consisted of 36 samples of Gaorani 12 F-2 cotton and 72 samples of Gaorani 6 cotton grown at Rudrur and Nanded respectively. These represented 9 different manurial treatments with 4 replications for Gaorani 12 F-2; and different treatments with 6 replications for Gaorani 6.

The samples were examined for mean fibre length, fibre weight per centimeter, swollen hair diameter, wall-thickness, maturity counts and bundle strength of fibres. The results show that

(a) Mean fibre length is significantly influenced by the application of nitrogen to both cottons.

(b) Maturity counts reacted to the interaction of nitrogen and phosphates in Gaorani 12 F-2 cotton; and fibre weight per centimeter and bundle strength were influenced by nitrogen and phosphates respectively in Gaorani 6 cotton.

(c) Fibre weight per centimeter is significantly correlated with swollen hair diameter in Gaorani 12 F-2.

(d) Swollen hair diameter is very highly correlated with wall thickness and area of cross section under cellulose in both cottons.

(e) Wall thickness is very highly correlated with area of cross section and maturity coefficient in both cottons.

(f) Area of cross section is significantly correlated with maturity coefficient in both cottons.

(g) Fibre strength is significantly correlated with maturity coefficient in Gaorani 12 F-2; while fibre strength divided by area of cross section is strongly, though negatively, correlated with swollen hair diameter, wall thickness and area of cross section in both cottons.

(h) These relations when studied further in the form of partial correlations, show that the highest correlation is yielded by swollen hair diameter and fibre strength divided by area of cross section after eliminating maturity coefficient alone in Gaorani 12 F-2 and maturity coefficient and fibre weight per centimeter in Gaorani 6.

52. Food and irrigation problems affecting India in general and Bombay in particular.

N. S. JOSHI, Poona.

India requires annually approximately 51-1/2 million tons and as a whole is short of rice. The brochure explains that increasing population will render worse the position of deficient provinces and states that as a whole, India is short of food by 3 percent now and the annual shortage will be of the order of 17 million tons after 30 years, during which period the population will have increased by about 30 percent. This is based on the present standard of nutrition which is inadequate. With a higher standard of living the shortage is estimated at 48 million tons in 30 years time. The problem can be solved by bringing more land under cultivation and increasing the out-turn of the area already cultivated, by such methods as improved seed and irrigation.

The details in Bombay are studied. It is shown that a 400% increase in irrigated area is essential. While this increase is possible in Ghat-fed tanks, that is not possible in up-country area. The solution of the problem is therefore dependent on an economic use of waters by concentration on existing and future irrigation Canals and secondly by the State constructing about 10 lakhs of new wells and giving them for use on annual rent to owners of lands.

53. A discriminant function for selection of yield in cotton.

V. G. PAÑSE and S. A. KHARGONKAR, Indore.

In plant breeding, the most important task is the selection of superior genotypes through the observation of phenotypic performance. Progeny means in replicated progeny row trials are reliable indicators of the genetic potentiality of progenies; but selection of individual plants for further propagation is rendered difficult owing to nongenetic modifications particularly in such complex characters as yield. The application of

Fisher's discriminant function is examined here for devising suitable selection formulae for seed cotton and lint yield of cotton plants. It was found from an analysis of data from varietal and progeny row trials that in selecting for yield of seed cotton the largest weight should be attached to weight of seed cotton per seed closely followed by boll number per plant and seed number per boll while the influence of ginning percentage was negligible. In lint yield, however, ginning percentage plays a positive role which is to be expected. Examination of the efficiency of the discriminant function did not reveal any material superiority over common methods of selection in the present material; but evidence of such superiority has been obtained in other crops like wheat and in selection for egg production in poultry. The investigation on cotton is being continued.

54. Random sampling for estimating rice yield.

P. V. SUKHATME, New Delhi.

The results of a sample survey carried out in Tanjore District and their bearing on the technique of random sampling for estimating the rice yield are described. It has been shown that the number of villages required to be sampled in each taluk of the district, and the number of fields to be sampled in each selected village for estimating the district mean yield with reasonable accuracy are such that the work involved can be managed by the existing staff of the Department of Agriculture during the course of their normal duties.

A relationship has been worked out showing the sampling variance in terms of the variances between and within villages and the number of villages and fields sampled. It has been shown that the mean yield attains the maximum accuracy when the number of experiments are so distributed that one experiment each is conducted in a different village of the taluk and that there are practical considerations other than the precision of the mean yield which have to be taken into consideration in determining the number of experiments and its distribution.

The results show that sampling by taluk definitely increases the precision of the yield estimate and that it is risky to use small size plot under the conditions of unevenly sown crops in India.

The results of the sampling survey can also be used for estimating the extent of cultivation practices, e.g. the area under improved varieties, manures, etc. and also for estimating the possible scope for increasing agricultural production by the adoption of improved practices in agriculture.

55. Germination of cotton in the field by sampling techniques.

P. S. SREENIVASAN and B. A. CHAUGULE, Poona.

Cotton in the Bombay Presidency is usually sown with a two-tined drill with tynes two feet apart. To study whether the rows sown by the same drill is more uniform than those sown by different drills, the germination counts were taken by two methods. It was found that the rows sown by the same drill show a variability of the same order as those sown by different drills.

56. Estimation of leaf area in sugarcane.

P. S. SREENIVASAN, Poona.

In developmental study, the importance of correctly estimating the leaf area is often felt. Various methods like tracing the leaf edge on a graph sheet or matching the models to the leaf have been tried. For a crop like sugarcane the easily measurable characters under field conditions are length and breadth. The paper discusses the efficiency of different sets of these measurable characters in estimating the leaf area. It was found that the breadths measured at $1/4$, $1/2$ and $3/4$ lengths along with the total length, yielded a more satisfactory estimate of leaf area for the POJ variety than the taking of maximum breadth.

57. Development of a suitable technique for the determination of the halo length of cotton.

R. L. N. IYENGAR and NAZIR AHMAU, Bombay.

The technological methods for the determination of the average length of a sample of cotton are too time-absorbing for routine use in a cotton breeding laboratory where thousands of samples have to be examined. Therefore, the method usually adopted is to take measurements on the seed cotton combed into a halo or a butterfly. Since

several different methods are followed in halo length measurements, the present investigation was undertaken to evolve a standard technique.

For this purpose, 12 samples of cotton were examined at seven cotton breeding stations by the methods followed at these places, while at the same time the same 12 cottons were also tested at the Technological Laboratory by the seven methods adopted at these places as well as by the original Bailey's method and the Laboratory's method. The results obtained showed that though the different methods did not exhibit large variation in their accuracy, there were considerable differences in regard to the time-factor. After a full consideration of all the factors the following three methods, viz. (1) Indore, (2) Lyallpur and (3) Modified Coimbatore, were further examined. The data obtained showed that the personal factor and the range of variability were greater for the Indore method, less so for the Lyallpur method and least of all for the modified Coimbatore method. It should, however, be noted that these points are not sufficient for assessing the superiority of any method over the others. As a further criterion the correlations between the halo length values, the mean length and the spinning quality of a large number of cottons are being worked out.

58. New prediction formulae for Indian cottons.

NAZIR AHMAD and HARI RAO NAVKAL, Bombay.

It is necessary for a cotton breeder or a spinner to know the quality of the cotton which is handled by him. This is judged best by spinning the cotton under standard conditions, but owing to various factors, it is not always possible to have recourse to this method. The fibre-properties of a cotton, which are more easily determined and require less materials, give a clue to the spinning quality provided a set of regression equations are worked out from which the spinning quality could be calculated.

In this paper, results for nearly 150 cottons have been analysed, and it is observed that the prediction is more precise if the Indian cottons are divided into four broad classes, the classification being based entirely on the fibre properties. These classes have been called (1) Inferior strains, (2) Superior fine strains, (3) Superior strains of medium fine-ness and (4) Superior coarse strains. For each class, the regression equations have been worked out correlating the spinning quality with those fibre-characters which are regarded as important for each group. It is found that, in general, these new formulae predict the spinning value better than the older formulae which were previously evolved at the Technological Laboratory. The differences between the actual and the calculated spinning performance have been reduced, and the relative importance of the fibre-properties for the different groups have been brought out.

Agricultural Pests and Diseases

59. Further trials with D. D. T. and 666 against insect pests.

M. C. CHERIAN and T. V. SUBRAMANIAM, Coimbatore.

The results of the trials with D.D.T. and 666 against a few stored, crops and household pests are given in the paper. Against the store pests such as *Sitophilus oryzae*, *Tribolium castaneum*, *Rhizopertha dominica*, *Necrotia rufipes* and *Corcyra cephalonica* the insecticides were effective either when mixed with grains or dusted on the outside of the bags.

The crop pests tested were *Calocoris angustatus*, *Ooptosoma cribraria*, *Scirtothrips dorsalis*, *Epieachna* sp., *Parasa lepida*, *Aryyria sticticrasis* and *Odontotermes obses*.

Against household insects such as the black ant-*Camponotus compressus* and *Leptima* sp. the insecticides were effective.

60. A technique for large scale fumigation of infested grains.

P. V. GEORGE, Madras and M. C. CHERIAN, Coimbatore.

A technique for large scale fumigation is described in this paper. The defects of alternative methods in vogue have been pointed out. The details of the new technique adopted are described. The use of the cement gunning machine worked with compressed air enables the discharge of large quantities of cyanogas with astonishing speed. The degassing effected with a series of suitably placed exhaust fans practically eliminates the dangers of cyanide fumigation to a minimum. The biological tests of efficiency of fumigation described give the whole technique a degree of scientific accuracy beyond the scope of methods in vogue.

61. A new method for assessing the results of cyanide fumigation of infested food grains.

M. C. CHERIAN, Coimbatore, and P. V. GEORGE, Madras.

This paper describes in detail a new method of evaluating the efficiency of cyanide fumigation of infested food grains. The method consists in estimating the respired CO_2 of samples drawn before and after the fumigation operations. Grains normally evolve a small per centage of CO_2 . After due allowance is given to this, if the samples after fumigation evolve little or no CO_2 , the fumigation done is considered effective.

62. Fumigation of infested grains with cyanogas.

D. SESHAGIRI RAO, Bangalore.

Owing to the non-availability of carbon-disulphide during war-time certain other fumigants were tried against insect pests of stored foodgrains. Of these, the proprietary 'Cyanogas' or calcium cyanide was found to give encouraging results in laboratory and large-scale trials, and therefore it is employed for the bulk-fumigation of infested grains (except rice and wheat products) in the Food Department.

The grain bags are stacked loosely, in alternate fashion in air-tight rooms leaving some space between the walls and the stack. Windows and the doors are made air-tight with wet earth and paper strips. 'Cyanogas' is pumped in with the foot pump duster at the rate of $2\frac{1}{2}$ to 3 lbs. per 1000 c.ft. Two days later, the room is opened, and after allowing for the remaining gas to escape, the room can be entered into safely. 94.7% mortality of weevils has been recorded in preliminary trials. The fumigated grain has been kept under observation for 3 months without any emergence of adults. Germination is not affected by this method.

11,218 bags of infested grains and 28,000 empty gunny bags have been fumigated successfully by this method during the last nine months, without any injury or mishap to any of the staff doing this work.

63. Susceptibility of raw and parboiled rice to insect attack during storage.

T. V. SUBRAMANIAM, Coimbatore.

The problem of storage of rice in large quantities for long periods is not generally a serious one in India under ordinary conditions. But owing to the difficulties created by the war this problem has assumed great importance. Rice in storage is damaged by various agencies such as climatic conditions, conditions of storage, rats, insects etc. This paper deals in a preliminary manner how the different kinds of rice such as raw and parboiled and the different grades of milling in these two categories are affected by the important insect pests, such as the rice weevil (*Calandra oryzae*), the redgrain beetle (*Tribolium* sp) and the paddy borer beetle (*Rhizopertha dominica*) as observed in a series of experiments conducted by the Entomological Section of the Agricultural College and Research Institute, Coimbatore, during the years 1943-44.

64. A survey of jassid fauna of Lypallpur.

M. ABDUL GHANI and MOHAMMAD AFZAL, Lypallpur.

The phototropic response of family jassidae, with special reference to cotton jassid, was studied in some detail at Lypallpur for a complete year. A light trap with 100 C.P. lamp was put up once a week from dusk to dawn. The total number of jassidae, the proportion of *Eumecurus devastans* and the proportion of females in the *E. devastans* collections were worked out from the weekly catches.

It was seen that jassids were attracted to light from the end of April to the end of September only. The percentage of *E. devastans* was highest (17.4 to 52.1) from the middle of August to middle of September. The percentage of females in the collections of *E. devastans* was preponderately high throughout the course of the year. Thus during the season when this pest is most active on the cotton plant light trap offers a fairly effective means of attracting it away.

An attempt was made to correlate the number of jassids collected with various climatic conditions such as minimum temperature, relative humidity, rainfall and moonlight. It was seen that very few jassids were attracted to light when the minimum temperatures fell below 70° F. and none at all below 52° F. The highest catches were obtained when the minimum temperature ranged from 72 to 88° F. It is shown in the paper that the size of the catches on different nights is mainly dependent upon minimum temperature. It was, however, not possible to separate the effect of moon light on the size of the catch from the various other factors that influenced it.

65. Comparative incidence of *Empoasca devastans* Dist. in different regions of the Punjab.

M. ABDUL GHANI and MOHAMMAD AFZAL, Lyallpur.

It is well known that the attack of *E. devastans* varies from field to field and from locality to locality.

A large number of varieties were under observation for three years in widely separated localities in the Punjab. The jassid attack was also of very different intensity during these years. The order of the severity of attack on different varieties did not show any great variation. A variety with a low population in one place in the Punjab in one year had low incidence of attack in other places in other years. A variety showing a high attack in one place showed a correspondingly high attack in other places in all the years. It is therefore safe to select and grow those varieties which show a low incidence of attack in spite of variations in soil and agricultural conditions in different parts of the Punjab.

Drastic changes of habitat, like importation of U4 from South Africa, however, is a different matter. Similarly resistant varieties from the Punjab when grown in Madras are heavily attacked.

66. Host-plants of *Empoasca devastans* Dist.

MOHAMMAD AFZAL and M. ABDUL GHANI, Lyallpur.

Cotton Jassid (*Empoasca devastans* Dist.) is active throughout the year. During the off season of cotton, it thrives on various other plants. A thorough knowledge of the host plants of a pest is essential as this information is very useful in devising measures of control. Host plants of cotton jassid have been mentioned by a few workers but not regular and sustained work appears to have been done in this direction with the results that no authenticated list of host plants of this pest is known so far. Mere presence of adults on a plant has sometimes been taken as an indication of its being a host plant which has led to lot of confusion. A plant can be a host plant only if the pest can actually feed and breed on it. Hence to determine the range of host plants of *E. devastans*, its oviposition and nymphal development were studied on 19 different species of plants at Lyallpur. As a result of these studies and those carried out previously in this laboratory the list of plants on which the pest can feed and breed and which act as its alternate hosts is now known and is given below in order of importance of the plant.

Hibiscus esculentus (Bhindi), *Althea rosea* (Hollyhock), *Solanum melongena* (Brinjal), *Solanum tuberosum* (Potato), *Hibiscus mutabilis* (Changeable rose), *Hibiscus tiliaceus*, *Helianthus annuus* (Sunflower).

67. Effect of sowing dates and spacings on the incidence of attack of cotton jassid (*Empoasca devastans* Dist.).

MOHAMMAD AFZAL and ABDUL GHANI, Lyallpur.

The effect of sowing dates and spacing on the incidence of jassid attack was studied at Lyallpur in a complex experiment involving 2 varieties (resistant, 4F & a susceptible, 124F), 3 sowing dates (14.V, 4.VI and 25.VI), 5 spacings (1'x1', 1'x2', 1'x3', 2'x2', and 2'x3') and 3 replications, during two years 1943 and 1944. Jassid population was determined by collecting the adults in 96 sweeps of the hand-net and counting the nymphs on 9 entire plants, per treatment. The data obtained were tested statistically.

It was seen that the "sweeping" method of estimating the population gave quite the reverse results to what were otherwise obtained by counting. The reason for this appears to lie in the fact that the number of plants swept over by a single sweep of the net differs in different spacings. Hence "sweeping" is not suitable in spacing experiments. The results obtained by "counting" were only reliable.

(1) 4F had significantly less population than 124F, during both years. (2) The first sowing (14.V) had significantly less population than rest of the two sowings. There was no difference between the last two sowings. (3) The jassid population was seen to increase consistently in both the years from 1'x2' to 2'x3' spacings. (4) Almost all the first order interactions were significant while those of 2nd order were non-significant.

It is recommended that spaced in areas where jassids are a serious menace the crop should be sown early and spaced closely.

68. The biology and control of the shot hole borer of coffee robusta *Xyleborus morstti*. Hagd.

M. APPANNA, Bangalore.

With the increase in extent of coffee robusta in Mysore, *Xyleborus morstti*. Hagd. is more commonly met with causing damage to both seedlings and old plant by

tunneling into the twigs thus causing them to gradually dry up. The habits of the beetle its life-history and incidence have been studied. The pest occurs throughout the year the peak and low periods of incidence being the monsoon and summer seasons respectively.

The insect is found to attack host plants other than coffee robusta like *Crotalaria anagyroides*, *Clerodendron* Sp, and *Pavetta* Sp. The insects bred on one host has been successfully reared on the other in the laboratory.

While studying the factors that influence the rapid multiplication of the pest, it has been seen that heavy shade and a heavy moisture content are admirably suited for the increase of the pest.

Pruning the infested twigs about 1" to 1½" away from the emergence hole towards the centre of the plant and regulating the shade so as not to have heavy shade seem to be two possible measures of controlling this pest.

69. *Ephelis* on two new hosts.

N. S. VENKATAKRISHNAIYA, Bangalore.

Two species of grasses *Isachne elegans* Dalz and *Eragrostis tenuifolia* Hochst were found infected by *Ephelis* near paddy fields in Mysore. The symptoms of infection were similar to those found on paddy. Measurements of spores corresponded to those found on paddy and the fungus is tentatively termed *Ephelis oryzae* pending further observation of the perfect stage of the fungus.

70. Preliminary note on the occurrence of a *Phytophthora* on French bean, *Phaseolus vulgaris*, Linn.

N. S. VENKATAKRISHNAIYA, Bangalore.

The French bean (*Phaseolus vulgaris*, Linn) has been noticed to be infected by a *Phytophthora* in low lying fields near Bangalore. The characteristic growth of the mycelium was noticed on the pods. Sections of pods and seeds showed the presence of oospores in abundance. The fungus was isolated from diseased pods and brought into pure culture. Sporangia and oospores were observed in culture. This occurrence of the fungus *Phytophthora* on *Phaseolus vulgaris*, Linn in Bangalore is the first record in India.

71. Notes on *Eurygaster maura* Linn. (Pentatomidae) with a key to identify its various varieties.

C. K. SAMUEL, New Delhi.

Eurygaster maura Linn. or 'corn bug' is an important pest of wheat crop in the palaearctic region, and has occurred in an epidemic form in Hungary, Italy, Central Europe, Southern Russia etc. In India the first report of its causing damage to wheat was received in 1926, and further reports there is no record as to the nature and extent of damage this species is capable of causing to wheat in India, nor it is known whether actually one or more species is concerned in doing the damage. In order to collect information on the subject, the author visited some important wheat-growing centres of Baluchistan, and the observations based on a survey of this pest carried out by him are described in the present paper.

The presence of a large number of variously coloured adult bugs and nymphs on the 'milky' ears in the fields led to the belief that several species, if not, at least different forms or varieties of the same species were concerned in causing the collective damage. A critical study of the morphology of a large series of bugs collected from the above mentioned localities has however revealed that in Baluchistan there are at least five varieties, viz., *maura*, *picta*, *personata*, *nigra* and *pallida* of the species *E. maura* responsible for damaging the wheat crop; and this is the first record of their occurrence in India. The key of Stichel (1925, 1938) has been modified and adopted by the author in identifying these different species.

The maximum damage to wheat ears (50-90%) and to grains (30-100%) was caused in Kohlu area and that the var. *pallida* was predominant (59%) in that locality. The extent of damage to ears and grains in Fort Sandeman was 10-25%, 30-35% and in Barkahn 10-15%, 5-10% respectively; *pallida* correspondingly predominated to the extent of 50% and 41% respectively in these localities.

The natural enemies of the pest include a nymphal parasite (*Sarcophaga* sp.) and the Indian house-sparrow, *Passer domesticus indicus*.

SECTION OF PHYSIOLOGY

PRESIDENT :—PROFESSOR P. DE, B.Sc., M.B. (Cal.) F.R.C.P. (Edin), F.N.I.

General Physiology

1. Evaluation of protein in human nutrition.

N. K. BASU, Delhi,

Recent experiments on the evaluation of soyabean proteins in human nutrition have thrown great doubts on the accuracy and correctness of the method of estimating the biological quality of proteins by means of observing the co-efficient of digestibility. Co-efficient of retention does not run parallel to co-efficient of digestibility, and as such it is a much better index.

2. Rheobase and Chronaxie of under fed and normal persons.

N. M. BASU, Calcutta.

Lapicque and others noticed that while the rheobase varies widely, chronaxie varies within a limited range. To ascertain if this variation in rheobase has any relation to the nutritive status of different persons, ill-fed college bearers and well-fed college boys were examined. It was observed that the rheobase of the former varied between 32 and 55 volts (average 44 volts,) whereas that of students varied generally between 5 and 30 volts (average of 40 students nearly 17 volts). One student who was having fits of insanity, showed a high rheobase of 45 volts during his sober period. The chronaxies of these persons did not correspond with their rheobase. Thus B.D., R.K.M., and D.S., with rheobases of 5, 7 and 15 volts had chronaxies of 0.56, 0.20, and 0.28 m. sec. respectively. Curiously enough, persons with very high rheobases had low chronaxies and with low rheobases usually higher chronaxies, but these relations are not exactly proportional. In these experiments the stigmatic electrode was placed on the motor point in the arm and the large indifferent electrode at the sternum. The experiment is in progress for the collection of further evidences and for ascertaining the significance of these observations.

3. Rheobase and Chronaxie of normal and vitamin B₁ and vitamin A deficient animals.

N. M. BASU, Calcutta.

Rats were used for these experiments. After they were mildly anaesthetised the motor point was quickly explored on a shaved portion of a hind leg by the stigmatic electrode, the large, looped indifferent electrode being placed on a shaved portion over the sternum. The rheobase was found to vary from 25 to 40 volts in normals and the chronaxie was found to vary from 0.06 to 0.1 m. sec. In vitamin A deficient animals no marked differences in chronaxie were noticed, but in vitamin B₁ deficient animals the chronaxie was found to be definitely lengthened, as it varied from nearly 0.15 to 0.20 m. sec.

4. A study of thermal changes on brain potential.

N. N. DAS, Calcutta.

The effects of low temperature ranging from 40°F to 70°F and high temperature up to 110°F on the spontaneous brain potentials of frogs, rabbits and cats have been reported. The technique consists in an application of a special type of devised Oscillograph with which it has been possible to show that complete stoppage of discharges from cortex of cat occurs in the region of the freezing point. This extreme cold is responsible for disturbed cerebral metabolism. After immersing a frog in a temperature of 104°F

for several minutes there was extreme decrease in amplitude of brain potential. After recovery, which takes about 20 minutes, potentials almost come back to normal. Just a few minutes before recovery irregular groupings appear which range between 12 to 18 per second. A short discussion is given.

5. Section of the hypothalamus to remove the hyperglycaemic effect of urethane.

P. DE, Calcutta.

Urethane produces a steady rise of blood sugar. In acute experiments in cats sections were made through the different levels in the brain and it has been found that the most anterior plane through which section is to be made to abolish the hyperglycaemic effect of urethane passes through the anterior border of the superior corpora quadrigemina above and mamillary bodies below.

6. The cause of hyperglycaemia under general anaesthesia.

P. DE, Calcutta.

Experiments have been done with different anaesthetics in animals. By varying the doses of the anaesthetics it has been proved that the blood sugar under general anaesthesia varies directly with the depth of the anaesthesia. Administration of additional doses of urethane in spinal preparations did not produce any rise of blood sugar level. Thus proving that the peripheral nervous mechanism did not take any part in the rise in blood sugar under anaesthesia. The hyperglycaemic effect under general anaesthesia has been shown to be due to the release of the hypothalamic sympathetic centre from the normal cortical control.

7. Causes of hyperglycaemia during operation.

P. DE and S. DATTA, Calcutta.

In cats operations done under general anaesthesia produced a greater rise of blood sugar than that due to anaesthetics alone. In ergotoxinised animals the same operations performed under the same anaesthetics produced a smaller rise of blood sugar. Also it has been shown that the operative interference in spinal animals produced a transitory rise of blood sugar level after about 20 or 25 minutes. A similar but more transient and smaller rise of blood sugar was observed in ergotoxinised animals after similar operations following decerebration at the colliculo-mamillary plane. These facts prove that the rise of blood sugar immediately after the operation is due to (a) the effect of the anaesthesia (b) the stimulation of the sympathetic nerve endings due to the operative interference and (c) the metabolic activity.

8. Analysis of cooked food.

R. K. GHOSH, S. AHMAD and K. MITRA, Patna.

In the dietary investigation reports often the supposed consumption of the different nutrient principles are calculated on the basis of raw foods weighed at the time of survey with the help of published table of food values. In the present experiment on 4 samples of full meals the wide divergence in the calculated values from raw foods and actual assessment of nutrients in cooked foods has been demonstrated. As far as proteins are concerned a loss of about 15% in cooked foods has been noticed. The loss in fat content has been as high as 40%. Losses of similar magnitude in calcium and phosphorus have also been noticed.

9. Autonomic innervation of frog's systemic blood vessels

J. C. GUPTA and P. K. ROY, Calcutta.

Preliminary observations suggest that perfusion with a high dilution of Adrenaline has the effect of producing initial dilatation of the vessels followed by constriction, concentrated solutions producing constriction at once. Atropine antagonises the dilator effect, the constrictor remaining unaffected. Ergotoxin has the opposite effect of antagonising the constrictor one, the dilator being left unaffected; so that, 'the vasomotor reversal of Dale' is obtained as usual. Perfusion with Acetylcholine also produces initial vaso-dilatation in high dilutions, concentrated solutions producing constriction. Atropine, here, antagonises both the constrictor and the dilator effects, while Ergotoxin affects neither. Further observations are, however, being continued.

10. Comparative study of cobra venom and cardiotoxin in relation to Ca, Na, K, and acetylcholine on toad's heart.

S. R. MAITRA and N. K. SARKAR, Calcutta.

Perfusion experiments were made with toad's heart and relative action of ions present in Ringer solution i.e. Ca, Na, K and also of Acetylcholine with cobra venom and Cardiotoxin isolated from cobra venom were studied. Acetylcholine and potassium stopped the heart in diastole. Cobra venom, Cardiotoxin separated from cobra venom and calcium stop heart in systole. Systolic stoppage of heart by Ca, can be removed by washing with Ringer when heart beat becomes normal again but stoppage of heart by cobra venom or Cardiotoxin can not be removed by perfusing the heart with the Ringer even for a long time and thus is irreversible. Calcium contraction can be counteracted by Acetylcholine or potassium but cobra venom or Cardiotoxin contraction is independent of these ions and Acetylcholine. It has been determined by using excess of Potassium or absence of Calcium or presence of Acetylcholine in the perfusing fluid. In all cases the cobra venom or Cardiotoxin produced the same type of systolic contraction.

11. Determination of isoelectric point of cardiotoxin isolated from cobra venom (*Naja tipudians*).

S. R. MAITRA, N. K. SARKAR and A. K. CHATTERJI, Calcutta.

The iso-electric behaviour of cardiotoxin, isolated from cobra venom (*Naja tri-pudians*) has been investigated. The nature of the electrical charge and migration of the particles of Cardiotoxin at different pH values have been studied by the micro-cathaphoretic method as well as by the moving boundary method. The iso-electric point of cardiotoxin, determined by these two methods, has been found to be in the neighbourhood of pH 8.2.

12. Salivary glands : as regulators of blood reaction.

S. N. MATHUR, Agra.

That the amount and reaction of saliva run, the first directly and the second indirectly, parallel to the amount and the reaction of the gastric juice and that it is possible and desirable to know about the changes taking place in the stomach simply by noting down the reaction of saliva, has already been shown by me in a number of previous papers. An important point that escaped critical study is the finding that the reaction of saliva changes considerably on either side of the possible changes taking place in the blood in normal and hyperchlorhydria cases, though not in hypochlorhydria. That this is not a passive reflection of the blood reaction is obvious. Salivary glands can thus actively and selectively secrete or concentrate either the alkaline or the acid radicals and help the blood in maintaining its normal reaction. It may be said that the salivary glands in this respect resemble the kidneys. They are, however, better than the kidneys for the economy of the body as they return the alkali back to the body when the strongly alkaline saliva secreted during and after meals is swallowed.

13. Gastro-skin reflex and water conservation.

S. N. MATHUR, Agra.

Amongst the various other mechanisms of water conservation in the body inhibition of secretion through sweat appears to be one. This inhibition starts working much earlier in anticipation, so to say, of the possible deprivation of water to the body; in other words this mechanism assures the necessary supply of sufficient amount of water to the cells for their efficient working till at least a still greater urgency of a further rise of temperature presents itself. That this mechanism starts working in advance can be shown by the facts observed that on a dry hot day drinking of water restarts in sweating immediately after in a reflex manner before there was any possibility of the absorption of water. This reflex may be termed as gastro-skin reflex.

14. Journey fatigue.

S. N. MATHUR, Agra.

The genesis of journey fatigue appears to be too frequent stimulation of the vestibular apparatus and the semicircular canals. This results in too frequent reflex adjustment of muscular tone and body posture. While this alone may result in fatigue if persisted for long an important factor that is added to it is the further instinctive super-adjustment of the body posture done unconsciously from the higher centres in an attempt to maintain a different posture from that which will be maintained if left to be done only reflexly.

15. Breaking-point.

S. N. MATHUR, Agra.

It is well known that the time the breath can hold depends upon the amount of carbon dioxide that accumulates in the blood. It has been observed that this time is appreciably higher in winter than in summer. This appears to be due to the necessity of the regulation of temperature, which is greater in summer than in winter, through breathing. This was further confirmed by the ability of tolerating larger percentages of carbon dioxide in inspired air in winter than in summer. Excess of carbon dioxide in the body appears to be less injurious than the rise of temperature.

16. Excretion of calcium and phosphorus in human adults.

K. MITRA and A. K. GHOSH, Patna.

In the present investigation an attempt has been made to find out the excretion of calcium and phosphorus by five adult human males on the diets given to them for protein metabolism experiments. In the low nitrogen period the diet consisted of 'halwa' and biscuits made from nitrogen free starch. In order to modify the unusual nature of such a diet, the subjects were also given small servings of potatoes, bottle gourd and edible green leaves. In subsequent test feeding period the subjects were given 'halwa' in the morning and 'khichri' made of sago with each of the different pulses namely Rahar dal, Masur dal, Boont dal and Mung dal, separately. The evening meals consisted of starch biscuits and the different pulse gruel in rotation and small servings of vegetables. In all the 31 feeding trials lasting for about a week in each subject, the total daily intake of calcium varied from 289 mg. to 820 mg. and the total daily output varied from 318.4 mg. to 601.1 mg. In the case of phosphorus the respective figures varied from 109 mg. to 679 mg. for daily intake and 176 mg. to 1047 mg. for daily output.

17. Studies on protein metabolism with interchange of cereals in the rice diet.

K. MITRA, S. K. VERMA and S. AHMAD, Patna.

Four adult healthy human subjects were kept on each of the experimental diets for a period of one week. Seven different kinds of experimental diets were fed to each of these subjects. The endogenous protein metabolism figures for each of the subjects were worked out on a 'low nitrogen diet'. The biological value of the proteins of a mixed diet consisting of rice, pulse and small servings of vegetables was found to be on the average 66.6. In the next feeding period, wheat chapatties were served in the evening along with the rice diet in the morning and the mean biological value of the mixed proteins of this diet was found to be 55.1. In the next five periods 25% by weight of the wheat flour in the chapatti was replaced by barley, maize, junera, maroos and bajra flours. The total biological value of the protein in these mixed diets was found to be 59.6, 56.7, 54.5, 60.4 and 57.0 respectively. The mean digestibility coefficient of the proteins in all these diets varied from 75 to 87.

18. The nervous factor in experimental hemorrhagic shock.

B. MUKERJI and N. K. DUTTA, Calcutta

Thirty experiments with sublethal hemorrhage at a more or less constant rate from a carotid artery coupled with electrical stimulation of the central cut-end of both sciatic nerves have been completed. Cats brought by such blood letting under a condition of experimental hemorrhagic shock usually are much more prone to succumb suddenly when additional nervous trauma is caused by strong stimulation of the sciatic ends or by giving a crushing pressure to the testes. The same trauma *per se* was not capable of killing the animals under normal conditions. Nervous or crushing trauma often caused death in cats with a relatively high mean level of blood pressure (60 mm. Hg. or higher), whereas when such extra stimulus is not present, the animals could be easily bled to a point corresponding to 25 mm. Hg. blood pressure.

It is therefore clear that something more than hemorrhage is responsible in most instances for bringing about the condition ordinarily designated as 'shock'. Crushing muscle trauma is also a potent factor under experimental conditions.

19. Stimulant action of acetyl choline.

B. NARAYANA, Patna.

The action of acetyl choline has been studied on frog's heart under varying perfusion pressures and it has also been studied in the normal beating heart by dropping

solutions of acetyl choline. It has been found that acetyl choline stimulates the heart under certain conditions. The results obtained have been explained.

20. The effects of changes in intrapulmonary pressure on the lung vessels of the guineapig.

B. NARAYANA, Patna.

The effects of changes in intrapulmonary pressure on the lung vessels have been investigated on the perfused lungs of the guineapig. Increase of pressure diminishes the flow of perfusion fluid through the pulmonary vascular bed and decrease of pressure facilitates the flow. These effects are produced mechanically.

21. Active elongation of unstriated muscle.

INDERJIT SINGH, A. M. J. SHIRAZI and K. B. SEHRA, Hyderabad, Sind.

The effect of ions on active elongation of muscle has been studied. The elongation is maximum in distilled water and diminishes as ions are added to it. The effects of potassium, sodium and calcium chlorides, hydrogen ions, adrenaline and acetyl choline were tried. Acidity diminishes elongation. Drugs show no significant effect. The experiments done support the view expressed previously that the elongation is dependent upon the entrance of distilled water into the muscle fibre, thus diminishing the concentration of ions which keep the myosin molecule folded. These experiments have further shown that the elongation is much too great to be accounted for merely by the swelling.

22. Physiological studies on the panting disease in cattle.

D. N. MULLICK and V. N. MURTY, Izatnagar.

The observation was made on two groups of animals. The percentage coefficient of organic matters including dry matter digested was less in diseased animals. The higher ratio of water intake and the dry matter showed that the animals required more water. The experimental animals suffered from nutritional anaemia and had a lower pH. The heat output was higher in diseased animals.

23. A physico-physiological theory of syllables in human speech.

S. SOURIRAJAN and C. R. SANKARAN, Poona.

This paper makes a comprehensive enunciation of a new syllable theory of ours on physico-physiological basis. The unsatisfactory character of the previous theories regarding syllable-movement in human speech, upheld by the other scientists like Stetson in the field, is shown and the scientific utility of our theory is stressed. The validity of the theory is tested and proved by experimental findings.

Vitamins

24. Observations on the vitamin A content of buffalo ghee and effect of the methods of preparation, storage and cooking.

BASHIR AHMAD, RAM CHAND and MANSUR-HASSAN, Lahore.

48 different samples of buffalo ghee were spectrographically studied for their vitamin A content. Out of these 41 samples were of genuine ghee prepared in the laboratory, while seven samples presumably pure were obtained from the market. 25 of the samples contained between 22-30 I.U. of vitamin A, 14 samples between 15-22 I.U./g. while 9 samples contained about 30 I.U./g, the highest value being 40 I.U./g.

Laboratory tests indicated that the usual Indian process of clarification of butter into ghee is not likely to cause any loss of vitamin A. Prolonged heating even at a relatively lower temperature causes greater destruction of vitamin A than heating to high temperature for short intervals.

Storing of samples of ghee under ordinary conditions at room temperature in the summer in Lahore did not result in any significant loss of vitamin A activity during the course of a month. At the end of 4 months loss varied from 2.5-22.5% and after 5-6 months the loss was between 25-30 per cent.

Investigations on the effect of the different Indian methods of cooking upon the vitamin A content of ghee showed that 63-69.5% was lost in the frying of puries. Making

of vegetables and dal curries, involving frying in ghee for 22-45 minutes, caused total loss of vitamin A activity, while in cooking in presence of water the loss was only 20-24 per cent. In Prathas the loss was only 8.7% and in Halwa 32.39 per cent.

25. Effect of feeding glucoascorbic acid to white rats, chicks and guinea pigs.

SACHCHIDANANDA BANERJEE, Calcutta.

The effect of feeding glucoascorbic acid to rats, chicks and guinea pigs were studied. Ten percent glucoascorbic acid when fed in a synthetic ration produced diarrhoea and failure in growth in rats. Similar effects in a less severe degree were noticed in rats receiving 10% ascorbic acid. Post-mortem examinations revealed no hemorrhages in any part of the body. When the rats receiving 10 per cent of either ascorbic acid or glucoascorbic acid were also fed 2% liver powder they grew almost like normal animals although they had moderate diarrhoea. Tissue ascorbic acid was apparently not diminished in the animals receiving 10% glucoascorbic acid. Ten-percent glucoascorbic acid when fed in a synthetic ration containing 2% solubilised liver had no deleterious effect in chicks. Severe diarrhea and loss in weight, as observed in guinea pigs fed on a natural ration containing 10% glucoascorbic acid, could not be prevented by the addition of 10% ascorbic acid in the diet but was prevented by the supplement of 6% liver powder. Glucoascorbic acid might produce some changes in the intestinal flora which affects the availability of some essential factors. When these essentials are supplied as liver powder the animals grow normally.

26. Observations on carotenoid pigments of yellow maize.

JAI CHAND SADANA and BASHIR AHMAD, Lahore.

The composition of fifteen different varieties of yellow corn grown in different parts of the Punjab with respect to different carotenoid pigments has been determined by the method of chromatographic separation and colorimetric estimation. Six pigments have been found to occur viz Zeaxanthin, Cryptoxanthin, β -carotene, α -carotene, Neo-cryptoxanthin and K-carotene, which were identified by absorption spectra and optical activity.

The various yellow and red varieties showed a total pigment content of 18.76-40.78 ug/g. of which as much as 10.29.4 ug/g. was zeaxanthin, representing 54.37-75.74% of the total pigments. The cryptoxanthin content varied from 3.61.7.5 ug/g. representing 15.29% of the total pigments; β -carotene was 1.35.3.72 ug/g representing 6.11% of the total carotenoids; while α -carotene was only 0.5 ug/g or less and did not represent more than 0.5.3% of the total pigments. The quantities of neo-cryptoxanthin and K-carotene varied from 0.3-1.1 ug/g and 0.18-0.55 ug/g representing 0.78.2.9% and 0.9.1.5% of the total pigments respectively.

The vitamin A potency of the various yellow and red varieties varied between 6.5-12.5 I.U./g. calculated from the amounts of active pigments present.

27. Stability of vitamin A in sesame oil.

S. SEN GUPTA, Baranagar (Calcutta).

It is now known that Oleum vitaminatum may be prepared by dissolving a vitamin concentrate in a vegetable oil like arachis oil. In connection with another work for isolating vitamin A from fish liver oil we had to use sesame oil and as such it was considered to investigate the stability of vitamin A in sesame oil. But working in this direction it is being noticed that the oil readily takes up oxygen with the development of a high peroxide value. The vitaminised oil also loses its vitamin potency and is completely lost even when purified air is passed only for a period of about 36 hours, whereas arachis oil retained the potency of an incorporated vitamin A concentrate for a considerable period of time.

28. A new microbiological method for the estimation of thiamin.

P. N. VOHRA, K. L. DHAMI, and BASHIR AHMAD, Delhi.

A microbiological method for the estimation of Thiamin has been developed based on the growth of yeast as determined by the Cell-count method. Under the conditions described in the paper, the growth of yeast is directly proportional to the amount of

thiamin present within a certain range of concentration of thiamin. After trying a number of strains of yeast, a few were found to be more suitable than others for this method. A synthetic basal culture medium is used and the method is found to give accurate results for 0.01–0.05 µg of vitamin B₁ per c.c.

29. Action of thiamin chloride on frog's heart.

S. H. ZAIDI, Lucknow.

A concentrated solution of Thiamin chloride, 1 in 1000 of Ringer's solution, arrests the frog's heart in diastole, while a more dilute solution increases the activity of the failing and tired heart. Similar result has been reported by Boyd and Dingwall but they have only pointed out the latter effect while the former effect has been attributed to acidity and hypertonicity. While agreeing with them so far as the action of diluted drug is concerned, I do not agree that the effect of concentrated solutions is due to acidity and hypertonicity, and this has been proved by using a 5% KCl solution. Burridge has pointed out that hearts, stopped by acids when treated with 5% KCl solution produce a dead-meat appearance. No such dead-meat appearance was seen with thiamin chloride while it was found in the case of lactic acid which was used as a control. A heart perfused with unbalanced Ringer (Ringer with a low calcium content) fails within half an hour while one perfused with same unbalanced ringer and thiamin goes on beating for hours. Thiamin plays the role of calcium sparer. In my experiment it was beating with the same vigour after 7 hours of perfusion.

A concentrated solution of thiamin before the heart is arrested in diastole, shows irregular twitching, and circus movements of the ventricle. The refractory period is generally shortened to produce a complete tetanus on faradisation. When the drug is washed off with Ringer the heart starts beating more vigorously. These findings show that thiamin has two actions on the heart, one is depressant and the other is stimulant, which remains and shows itself only when the drug has been washed off. It has also been noticed that thiamin has a marked detrimental action on the ranine alimentary System.

Biochemistry

30. Mammary fat secretion in the buffalo.

K. T. ACHAYA and B. N. BANERJEE, Bangalore.

Taking into consideration species differences like a low occurrence of associated carotene and vitamin A, a low production of oleic acid, a high production in general of lower acids and a great susceptibility to feeding vagaries, the process of milk fat secretion in the buffalo is probably identical with that of the cow. This postulate is based on the following reasons : (i) An inverse relationship between the lower acids of buffalo milk-fat and its oleic acid could best be explained by the theory of Hilditch and co-workers that the former are derived by the oxidation of pre-formed oleo-glycerides. (ii) The presence of lower unsaturated acids, probably identical with the Δ^9-10 acids of cow and goat milk-fat which are structurally similar to oleic acid can also be explained similarly. (iii) The long known presence of lower saturated acids.

Biological reduction of dietary unsaturated acids occurs to a marked extent; the unsaturated cottonseed oil resulted in ghees of high stearic acid content, the source of which could only have been dietary oleic or linoleic acid.

31. Observations on the relative digestibility of common edible fats by pancreatic lipase.

A. N. BAHL and BASHIR AHMAD, Lahore.

The nutritive value of hydrogenated vegetable oils has attracted considerable interest in this country, though there are very few scientific studies on the subject. In this investigation the relative digestibility of these fats has been studied by pancreatic lipase in vitro. Five samples of milk fats from cows and buffaloes, twelve different brands of hydrogenated oils, eleven vegetable oils, and four animal fats were selected. The digestibility of these varied considerably. Coconut and Sesame oils showed greatest degree of digestibility under the same conditions and tallow the least. The digestibility of the hydrogenated fats was poor as compared to oils and milk fat, though some of the samples compared very well with butter.

32. Rate of absorption of different fats and oils.

K. P. BASU and H. P. NATH, Dacca.

This paper deals with the study of the comparative rates of absorption of several fats and oils which are used in different parts of our country, e.g. mustard, coconut, sesame, groundnut oils and cow-butter fat.

The technique used was to feed the fat in question, about 2 c.c. by stomach tubes to rats, weighing from 225 to 250 gms. and fasted previously for 48 hours, when only water was given to them. Amount of fat absorbed after periods of 2, 4 and 6 hours were determined. At the end of the definite interval the rats were killed, the intact gastro-intestinal tract removed and the fat remaining (i.e., unabsorbed) were determined by water and petroleum ether extraction.

Effect of the concentration of fat administered on the rate of absorption of coconut oil was also investigated.

The results showed that 2 hours after administration, olive oil and cow-butter fat were the most rapidly absorbed ones (41.1% and 40.8% respectively) while the mustard oil was the least absorbed (27.6%) and the absorption of others were intermediate between these. This is to be expected since the former ones contain large percentages of shorter chain fatty acids and as these are somewhat water-soluble, they are likely to be absorbed more rapidly than the long chain fatty acids. The results, however, become striking four hours after ingestion when it is seen that mustard oil is absorbed to the greatest extent (56.3%). Difference between the rates of absorption of olive, sesame, groundnut oils and cow-butter fats continued to diminish at that time and at 6 hours period they were practically identical.

The rate of absorption of oil increased slightly with increased concentration of oil ingested.

33. Potato meal in the study of gastric secretion.

N. P. BENAWRI, Lahore.

In view of the fact that both Alcohol meal and Oat meal are unusual articles for the Indian stomachs a new meal—the Potato meal was devised and results of Gastric analyses with this test meal were compared with those using alcohol meal (in 20 normal healthy individuals) and oat meal (in another series of 20 normal healthy individuals). It was found that Potato meal gave distinctly better results than either of the other two meals both regarding the acid secretion and the secretion of the proteolytic enzymes.

Results of the analyses of the 80 fasting stomach contents (two for each of the 40 cases) have been analysed. Normal range of free gastric acidity in the Punjab using potato test meal has been worked out and charted on a graph. Mean acidity figures for the potato meal were—mean fasting 18.84, mean highest 47.69, time for maximum acid peak one hour.

An interesting case suggestive of separate mechanisms for the secretion of the Pepsin and the Cathepsin has been reported and incidentally it adds further weight to the superiority of potato meal over the alcohol meal. It is suggested that in India potato meal would give a truer picture of gastric secretion than either alcohol meal or oatmeal.

34. On the determination of acetone bodies in small amount of blood.

M. K. CHAKRABORTY and M. C. NATH, Dacca.

By a comparative study of the existing methods for the determination of acetone bodies in the blood, a suitable micromethod has been deduced for the purpose. Only 5 c.c. of blood are required for the estimation.

The blood is deproteinised and desaccharified. The resulting product is distilled after conversion of the aceto-acetic acid and β -hydroxybutyric acid into acetone, and the acetone is collected in the distillate.

From this distillate the amount of acetone may be determined either colorimetrically by the colour formation of acetone with alkaline salicylaldehyde or gravimetrically by the mercury-salt formation. But the former one appears more suitable.

This method may conveniently be used by clinicians for the determination of acetone bodies in the blood of diabetic patients.

35. Role of dahi in Indian dietary

N. N. DAS, Calcutta.

It is one of the most important milk products in the dietary of Indians from very early days. Curd (Indian term, Dahi) is a nourishing and refreshing food and is easily

digested. It is something like the Yoghurt prepared in Europe and America. It was first known by Turks and Balkans; Egyptians gave the name 'leben'. 'Kumiss' has been prepared by Russians by acid and alcoholic fermentation of mare's milk. 'Kefir' was once the chief food of natives of Caucasus region which was prepared from goat's and cow's milk. The fermenting organisms were isolated and worked out in detail and cause of flavour and consistency due to particular strain was brought out. The food value and chemical composition of Indian Dahi is determined. The antibiotic properties of Dahi has also been tested in vitro with organisms like Typhoid, Dysentery and Cholera etc. The variety of factors regarding its role in Indian diet has been delineated.

36. Preparation of zinc *d*-lactate from butcher's meat.

A. GAFFUR, Nagpur.

Protein free muscle extract was prepared by mixing anhydrous sodium sulphate with mince so as to form a saturated solution with muscle water at 32°C, and then pressed out when warm and the extract filtered. The filtrate was cooled to 0°C. The mother liquor contains lactic acid in concentration about 3 times greater than muscle. The mother liquor was acidified and extracted with ether. Ether extract was evaporated to a small volume and neutralised with zinc carbonate. Acetone was added to filtrate and crystals of zinc lactate separated.

The salt was purified by repeated precipitation with alcohol desiccated and its purity tested polarimetrically, and by estimation of lactic acid content.

37. Crystalline thyroxine from Indian cattle thyroid glands.

S. K. GANGULY and S. DHAR CHAUDHURY, Baranagar (Calcutta).

Difficulties were met with in the isolation of crystalline thyroxine from Indian cattle thyroid. On hydrolysis of the minced glands with 5 percent caustic soda the extract set to a jelly like mass on cooling. Similar conditions were met with by Kendall with some samples of American desiccated thyroid. The barium insoluble fraction was bulky and its decomposition with sodium hydroxide and sodium sulphate was also unsatisfactory.

The method used is described in details with some modifications of Kendall's process by which such difficulties were encountered. The yield of crystalline thyroxine obtained from several batches of the glands were more or less uniform. Four batches consisting of 5840, 3260, 3793 and 4028 grams of minced raw thyroid were separately extracted according to the method of Kendall and the yield of the crystalline thyroxine was 160, 88, 109, 124 mg. respectively. The average yield comes to 0.0028 percent on the raw cattle thyroid.

38. On proteolysed liver.

S. K. GANGULY and P. SEN GUPTA, Baranagore (Calcutta).

Various mammalian livers from local slaughter house were collected from time to time and their general composition as regards moisture, protein, fat, carbohydrate, mineral matters including iron were ascertained. Sheep liver is richer than cow or pig liver in all respects except the iron content, Pig liver is richest in iron content. Each of the above livers was then digested by papain and the respective hydrolysate was evaporated in vacuo to offer a proteolysed liver in the form of a very hygroscopic powder. On estimation of various nitrogen fractions as present in each of the above it was noticed that α -amino acid (Van Slyke) fraction was richer in cow-liver digest whereas the sheep-liver digest was richer in peptone nitrogen.

Using them as a growth factor for the growth of *Lactobacillus casei*, it was noticed that cow-liver hydrolysate powder produced more acid in comparison with the other two. This cow-liver hydrolysate powder was again on comparison with whole liver extract and various alcoholic extract fractions were found to be richest in possessing factors that are responsible for the growth of *Lactobacillus casei*. It appears that bovine liver papain digest would be better therapeutic agent than the similar digests obtainable from the other two.

39. Inactivation of insulin by intermediary fat metabolism products.

M. C. NATH and H. D. BRAHMACHARI, Dacca

Prolonged injection of ketone bodies have previously been found, in this Laboratory, to cause hyperglycemia in rabbits. Effect of these ketone bodies in neutralising or inhibit-

ing the potency of insulin has further been shown in this paper, thus giving some clue to the insulin insensitive mechanism in some cases of diabetes.

40. Enzymic casein hydrolysate.

N. Roy, Baranagar, Calcutta.

Casein has been hydrolysed under the influence of pepsin, papain activated by sodium thiosulphate according to Basu *et al* (*Ind. Med. Gaz.*, 1945, in press), and trypsin. The different hydrolysates have been analysed for their nitrogenous constituents. The average size of the molecule of the digested product is largest in the pepsin digest and the smallest in the tryptic one. All of them vary in their other characteristics too. None is free from proteoses.

41. The copper content of some of the common animal feeds

KARTHA SAHAI and N. D. KEHAR, Izatnagar.

The copper content of 73 samples of grasses, straws, tree leaves, grains and oil cakes has been estimated. The amount of copper ranges from 3.6 mg. per kg. (dry matter basis) in oat straw to 17.8 mg. in *padal* (*Stereospermum suaveolens*) leaves. There are significant variations in the copper content of various foodstuffs. According to a tentative classification of these foodstuffs in the ascending order the cereal straws constitute the first group, the grasses and the tree leaves the second group and the concentrates the third group.

42. Effects of progressive maturity on the copper content of some of the indigenous grasses and leafy fodders.

KARTHA SAHAI and N. D. KEHAR, Izatnagar.

The copper content of 17 grasses cut in August, September and October was determined. It was found that the copper content decreases with the progress of maturity. The effect of soil conditions and other environmental factors on the same species of grass obtained from different localities has also been studied.

The copper content of 18 tree leaves lopped in November, January and March was also determined. The variations in the copper content of some of them did not seem to follow any regular course with progressive maturity.

43. Observations on pectin isolated from different plant sources.

YOGENDRA NATH TREHAN and BASHIR AHMAD, Lahore.

Pectin from five different sources e.g. chakotra rind, lemon rind, potatoes, guavas, and onions was isolated by extraction with N/75 hydrochloric acid and precipitation with 95% ethyl alcohol. The average percentages of the various groups found on analysis were galacturonic acid 68.46%, arabinose 9.19%, and galactose 11.4 per cent. The methoxyl content in the case of chakotra rind pectin was 8.8% while in all other cases it averaged 11.3%. The empirical formula of pectin was calculated to be $C_{50}H_{59}O_{30}$, except in the chakotra rind pectin where it was $C_{58}H_{55}O_{30}$.

Pectin content of 32 Indian plant sources, (9 vegetables, 9 roots, 6 nuts, 6 fruits, and 2 seeds) has been determined by precipitation as calcium pectate. The values varied in vegetables from 6.05% cauliflower to 13.3% in broad beans; in roots from 5.6% in radish to 16.7% in beet root; in nuts from 1.08% in raw pistachio nuts to 4.08% in brazil kernels; and in fruits from 10.87% in country guavas to 35.0% in lemon rind. The seed meal of tamarind on analysis did not give the test for pectin.

Studies in vitro on the effect of pectin solutions on the clotting time of human blood showed that a distinct fall in the clotting time of human blood was brought about by them. The time of clotting decreased with a rise in the pectin content of the solution. This action seems to be somewhat analogous with thromboplastin or snake venoms, in so far as the lowering of clotting time is concerned.

Pharmacology

44. Studies on the stability of adrenaline solution.

U.P. BASU, S.K. GANGULY and A.N. BOSE, Baranagar, (Calcutta).

Adrenaline Solution (Pharmacopoeial preparation) undergoes deterioration on storage. Various causes are responsible for this change and it is being recorded in this

laboratory that one of the factors for this deterioration is due to the change in its optical rotation. The pressure activity of dextro or dextro-laevo variety of adrenaline is much lower than that of laevo-adrenaline. As such any alteration in the optical rotation of the laevo-variety that is used in pharmacopoeial preparation, would cause a physiological change in the usual adrenaline solution.

On this hypothesis a preparation of laevo-adrenaline with a laevo-acid would offer a more stable solution. This has been achieved by incorporating laevo-malic acid in preparing an adrenaline solution (0.1%). The paper also describes the changes in optical rotation of various adrenaline salts in solutions under different conditions. An adrenaline malate solution (0.1%) is maintaining its original potency for a period exceeding a year and a quarter.

45. *Rauwolfia canescens*—a sympatholytic drug.

M. D. CHAKRAVARTI, Agra.

Various preparations of *Rauwolfia Serpentina* have recently been marketed for the treatment of hypertension. Alcoholic extracts and pills prepared from the root of the plant containing all the alkaloids are being used for the purpose. The pharmacological properties of the Bengal variety of *Rauwolfia-R. canescens* growing abundantly in the suburbs of Calcutta have been studied. An alkaloid-Rauwolscine has been isolated from the plant. Both the alcoholic extract prepared from the leaves of the plant as well as the alkaloidal salt have been found to lower the arterial pressure of experimental animals. The reduction in blood pressure is seen in the decerebrate and spinal animals as well as in atropinised animals. The drug appears to have a depressant action on the vessel walls. Further it has been observed that it completely abolishes adrenaline effects on the blood pressure of animals. The drug therefore appears to lower arterial pressure by paralysing the sympathetic nervous system as well as by direct depressant action on the involuntary muscles of the blood vessels.

The lethal dose has been worked out in dogs and is found to be 3.88 ccm of the extract liquid with an alkaloidal content of 0.24 per cent per kgm body weight with a standard deviation, -2.3 and standard error, 0.6. Primary respiratory failure was found to be the cause of death in the animals, heart stopping later.

46. Fate of Rauwolscine—an alkaloid of *R. Canescens* in the body (concentration of Rauwolscine in blood)

M. D. CHAKRAVARTI, J. N. TAYAL, Agra and (Mrs.) A. CHATTERJI, Calcutta.

The concentration of Rauwolscine hydrochloride in the blood and urine of experimental animals has been determined with chemical tests. The drug lowers the arterial pressure of animals. An injection of 25 mgms of the drug was immediately followed by marked reduction of arterial pressure and the effects passed off in about 15 minutes after the injection. Maximum concentration of the drug in the blood and in the urine was attained after 20 minutes and 40 minutes respectively of the injection. The alkaloid could be detected circulating in the blood even 2 hours after the injection. Though the drug circulated for 2 hours in the blood no effects were seen on the blood pressure 15 minutes after injection of the drug. No definite relationship can be drawn between the concentration of the drug in the blood and its peripheral effects.

47. The comparative action of some alkylhydrocupreidines.

P. DE, Calcutta.

The intensity of action is increased from hydroquinidine and ethylhydrocupreidine as the derivatives higher and higher in the series were tested. The octylhydrocupreidine behaved a little differently probably due to its relative insolubility. In adequate doses a fall of blood pressure was observed with all the members of the series, except the octylhydrocupreidine which produced a rise of blood pressure after a little fall. The fall of blood pressure was due partly to the depression of the myocardium and partly to the dilatation of the vessels of the organs. All these derivatives in adequate doses had a depressing action on the plain muscle of the intestine and the cardiac musculature. There was a rise of pulmonary pressure due to constriction of pulmonary vessels. Pulmonary oedema was observed with higher members of this series.

48. Pharmacological action of *Vanda roxburghii* Br.

J. C. GUPTA, P. K. ROY and K. K. SEN GUPTA, Calcutta.

Vanda roxburghii Br., known as Rasna in Bengal, is now said to be a scarcely available plant in these parts. A substitute is, however, being widely used here in Ayurvedic medicines in the name of Rasna.

The substituted plant contains a glucosidic principle having marked physiological activity; it also contains a bitter principle, tannin, resin, saponin, sterols and waxes.

The active glucosidic principle lowers the blood pressure, increases the tone and movements of the intestines, the bladder, and the non-pregnant uterus of the cat. The heart-rate is diminished, but its force increased. The spleen is contracted, though the systemic blood vessels in general are dilated.

It appears that the drug is essentially cholinergic in nature, exerting also some direct influence on certain muscles. Further action is being observed.

49. Stimulation of respiration caused by minute doses of the venom of the common Indian Cobra (*Naja Naja Vel Tripudians*) after the depression produced by morphine and luminal-sodium.

FAZLE KARIM KHAN, Hyderabad-Deccan.

This venom is known to be depressant for the central nervous system in general and specially for the cells of the respiratory center, the cells of the nuclei governing the movements of the lips, cheeks, eye-lids, tongue and throat. The factor responsible for this is the neurotoxin.

To study the action of the crude cobra venom, a solution of the venom was slowly given intravenously. In the first part of the infusion, it was noticed that a stimulation of respiration occurred followed by a depression, that is to say a minute dose of the venom is stimulant and a large dose a depressant for respiration.

Depression of respiration was produced by means of morphine and luminal-sodium, and an attempt was made to neutralize these two depressions by means of minute doses of cobra venom.

It can, therefore, be concluded that

- (1). Cobra venom can antagonize the depression produced by small doses of morphine. Its effect on depression produced by large doses could not be studied because of drug scarcity.
- (2). Cobra venom does neutralize to a certain extent the respiratory depression produced by small doses of luminal sodium, but cannot avert death which is produced by large doses.

50. Study of cobra venom and cardiotoxin on toad's heart and voluntary muscle in relation to digitoxin, saponin, and strophanthin.

S. R. MAITRA and N. K. SARKAR, Calcutta.

By the usual perfusion experiments on toad's heart difference in action between Cobra venom and Cardiotoxin with Digitalis, Saponin and Strophanthin was shown. Digitalis stops the heart at a certain concentration and so also Saponin and Strophanthin. Saponin has got additional action of paralysing the nerve. But these actions can be washed out when the heart is perfused with Ringer. Stoppage of heart with Cobra venom and Cardiotoxin is irreversible and can not be washed out by perfusing with Ringer. Actions on voluntary muscle were studied on baths made on muscle chamber. The muscle goes to contracture as soon as the venom solution is added. With strong solution the contracture is complete and it can not be revived to normal even when cobra venom or cardiotoxin solution is replaced by Ringer. The action of cobra venom or cardiotoxin is neither like Digitalis series or Saponin series.

51. Hypnotics and the action of insulin.

B. MUKERJI, Calcutta.

Under standardized conditions, the blood sugars for 1, 3 and 5 hours of a group of ten rabbits were determined under each of the following conditions; normal, with insulin, with barbital sodium, with barbital sodium + insulin, with morphine sulphate and with morphine sulphate plus insulin. The blood sugar of the normal rabbit, as previously reported (Iyengar, Bose & Mukerji, *Annals of Biochemistry & Exper. Medicine*, 5, 45, 1945) is relatively constant within a stated range. Morphine sulphate, 112 mgm/kg. and Barbital sodium (0.1 gm/kg) produced only a slight depressing action on the blood sugar but when insulin was administered, these drugs in these doses had an apparently anti-insulin action. Morphine sulphate in higher doses, 25 mg/kg. caused variable changes in the blood sugar; in some hypoglycemia was noticed, in others hypoglycemia. This dose of morphine sulphate tended to intensify the hypoglycemic action of insulin.

Reported results in the literature (Murphy & Young, *Jour. Physiol.*, 76; 395, 1932) indicated variable effects of hypnotics on insulin. The study has been taken up to obtain conclusive data on this issue and is being continued in collaboration with

colleagues in the Biochemical Standardization Laboratory of the Government of India at Calcutta.

52. Pharmacological investigation of *Berberis umbellata* (N.O. Berberidaceae) and its alkaloid umbellatine and its use in the treatment of oriental sore.

K. N. OJHA, Agra.

Recently Umbellatine-the active principle of *Berberis Umbellata*, has been used with much success in the treatment of Oriental Sore.

The toxicity of both the alcoholic extract of the plant as well as its alkaloidal salt has been worked out. The alcoholic extract of the plant has toxicity lower than its alkaloidal salt when injected into the wing vein of the bird. The drug causes a fall in blood pressure even after paralysis of the parasympathetic and sympathetic nervous systems. This is also marked in spinal animals. The fall in blood pressure in the intact animal therefore appears to be due to direct depressant action on the vessel walls and also probably due to stimulation of the vagal centre. That the fall in blood vessels is also confirmed by perfusion experiments.

The drug in small dosage tones up and stimulates the cardiac and other involuntary muscles whereas in large dosage it depresses them. The drug has been found to be stimulant of respiration.

One per cent solution of Umbellatine Hydrochloride in double distilled water was tried in six cases of Oriental Sore. The diagnosis was confirmed by laboratory findings and the drug was later injected. In all cases about three injections caused complete healing of the ulcers.

53. The actions of some of the principles isolated from *Crinum defixum*, Ker Gawl.

K. VENKATACHALAM, Madras.

A preliminary pharmacological study has been made of three toxic constituents isolated from the bulbs of *Crinum defixum*. One of these is a resin, the other is a crystalline resinol- $C_{20}H_{30}O_4$ and the third-an amorphous alkaloid. The actions of the resin and the resinol are more or less similar. The most important effect produced by these, in very small doses, is slowing of the heart with increase in the force of its contraction and rise of blood pressure. These results appear to be due to the direct action of these principles on the cardiac muscle. In contrast to the action of the resin and the resinol, the alkaloidal residue has a depressant effect on the heart.

Anatomy

54. The diagonal sulcus of the cerebrum, its frequency in the south Indian brain and its significance.

A. ANANTHANARAYANA AYER, Madras.

The diagonal sulcus is a sulcus that occurs in the pars basilaris which is the posterior part of the inferior frontal gyrus, an area which is generally regarded as the area concerned with motor speech and it is a sulcus recently acquired in human evolutionary life. The speech area is said to be located in the left (dominant) hemisphere in right-handed people. In the material studied no naked eye difference, either in size or complexity of sulcal pattern, could be made out in this region between the right and left cerebral hemispheres.

The sulcus diagonalis occurs in 36 out of 40 hemispheres i.e. in 90 per cent; and so it can be said to be a more or less constant feature of the pars basilaris of the South Indian brain. In the few instances where it is missing it probably has indistinguishably blended with one of the peripheral sulci. It occurs as one or more linear sulci, either vertical or oblique, or I-or Y-shaped, or it might apparently unite partly or wholly with one of the bounding sulci. The diagonal sulcus is observed to shift its position with a wide anteroposterior range in the pars basilaris in different specimens.

On an analysis of the architectonic maps of the cortex by Brodman, Elliot Smith and Campbell, the author finds that there is considerable irreconcilability regarding precise boundaries of structurally distinctive areas in the pars basilaris. According to Elliot Smith the diagonal sulcus would be regarded as a limiting sulcus between two distinctive areas; but according to maps of Brodman and Campbell there is no justification for such a view. From its naked eye external morphology and its tendency for wide migration within its field, the author opines that the sulcus diagonalis is probably a compensatory sulcus developed anywhere in the pars basilaris.

55. Preliminary observation on the haemodynamic factors in the formation and distribution pattern of limb arteries.

G. K. GHOSH and B. N. DAS GUPTA, Patna.

One of Thomas laws formulated in 1893 states that "The increase in size of the lumen of blood vessel is directly related to the rate of blood flow." Woollard and Harpman (1941) later showed a relation between the size of the artery and the capillary bed in the embryo. It was felt that there may be a constancy or relation even in the adult between the circumference of the vessel, and the area of its distribution. Measurement of the diameters of the vessels, the angles of their division, and the planes in which the branching is taking place—the surface area and where possible the volumes of the limbs were made on cadavers by gnomometer, and other instruments. Graphs were plotted and mean value was calculated.

- (1) The circumference of an artery bears constant ratio to the area of its distribution.
- (2) The pattern of distribution to pre-axial, post-axial areas, flexor and extensor surfaces are similar in both the limbs. The angles of branching of the vessels and the planes into which they divide, also bear similar relations.

56. Some preliminary observations on the relative ratio between the length of the different long bones and the stature of Biharees.

G. K. GHOSH and B. N. DAS GUPTA, Patna.

These investigations were carried out in the Anatomy Department, P.W. Medical College, Patna to establish the same data for Bihar. Very often expert opinion from this department had to be given to judicial authorities on observations made mostly in Europe and America, very few being available for India and practically none for Bihar.

Materials:—Cadavers. To correlate between the living and dead a series of measurements on medical students were also taken.

Instruments:—Height measure, Calliper graduated in centimeter and measuring tape.

Actual measurement:—Accepted as standard of measurements in surgery were adhered to. A constant factor from each of these measurements were subtracted to give an idea of the actual length of the bone.

Conclusions:—From the above measurements, a mean value was obtained. The relation between the length of long bones and the stature of Biharees was established.

57. Variations in the lower end of femur in squatters.

M. A. SHAH, Hyderabad-Sind.

Variations noticed in the lower ends of 200 femora of Punjabis (who habitually squat) are discussed, and compared with the published results.

A. *Previous work.*

1. Increased depth of intercondylar notch in such bones (Martin, 1932; Siddiqui, 1934, 1936) was confirmed. To bring such measurements in line with other osteometric data, adoption of a "Squatting Index" was suggested (Shah, 1942). In Punjabis it is 24.

2. Popliteal facet (Shah, 1945), hitherto unmentioned, was described on the posterior part of the lateral aspect of the lateral condyle, and its existence explained as due to rubbing of the popliteal tendon.

B. *Present investigation.*

1. Quadriceps facet (Martin, 1932) was present in 77 per cent. of
2. Patellar groove. Its depth was measured and expressed as a fraction of the length of the bone.
 - i. In 62 percent it was deeper than $1/45$ and in 3.5 per cent shallower than $1/60$. In English (Martin, 1932) the bones are neither so deep (3 per cent), nor so shallow (7 per cent).
 - ii. In 87 per cent it was deeper than $1/52$ and in 13 per cent shallower than $1/51$. Corresponding figures for modern Irish are 50 per cent and 0 per cent, and for modern English 30 per cent and 70 per cent.

SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

PRESIDENT : DR. INDRA SEN, M.A., Ph.D.

General and Experimental Psychology

1. Psycho-galvanic reflex and its application to crime detection. Laboratory crimes.

N. C. SANKARNARAYAN RAO, Mysore.

The laboratory crime consists in the commission of an act by one of the two patients in secret (such as hiding in his pocket a valuable article kept in a box) and the attempt on the part of the Experimenter to detect the 'thief'. After 'balancing' the patient on the Wheatstone's Bridge the following forms of stimuli are presented: (a) ten non-crucial statements and ten crucial statements, (b) ten non-crucial words interspersed in a random order with five crucial words. The resulting galvanic reactions as the patient repeats the statement or word are recorded. Thus the experiment is conducted with both the patients. The ratio between the average emotional reaction for crucial stimuli and the average emotional reaction for non-crucial stimuli is calculated, for each form of stimuli, for each patient, and he who gives a relatively higher ratio is judged to be 'guilty'.

According to the procedure outlined above, 90 experiments have been conducted and 80% success is obtained on the basis of criteria mentioned above. Both words and sentences are found to be equally diagnostic.

2. Psycho-galvanic reflex and its application to crime detection. Real crimes.

N. C. SANKARNARAYAN RAO, Mysore.

The paper reports the results of experiments on persons who are suspected by the police, of having committed a particular offence. An attempt has been made to study whether it is possible to differentiate the 'guilty' from an 'innocent' person on the basis of their emotional reactions for crucial and non-crucial stimuli. After 'balancing' the patient on the Wheatstone's Bridge, a series of statements are presented for Repetition. These statements are of two sorts: (a) ordinary statements and (b) crucial statements bearing upon the crime situation. The galvanic reactions as the patient repeats these statements are recorded. Several Criminal Indices are obtained by dividing in each case the reaction for crucial statements by those for non-crucial statements. These Indices are validated with reference to the objective evidence of 'guilt' or 'innocence' as ascertained by the result of police investigation. As such evidence is available in a few cases, the results cannot be considered to be conclusive as to the relative diagnostic value of several Criminal Indices proposed. It is suggested, however, that P. G. R. may be definitely helpful in eliminating the 'innocent' at a very early stage in police enquiry.

3. Individual differences in reaction to ink blots.

SAYED AHMED and PARS RAM, Lahore.

8 ink blots black in colour were given to College students and School boys. Age and sex differences in reactions are analysed. Possibilities of ink blot test as a test of certain personality traits are discussed.

4. The urge for freedom.

B. KUPPUSAWMY, Mysore.

McDougall does not mention any 'Freedom Instinct', but Pavlov tries to show that there is a 'Freedom Reflex'. An attempt is made in the present paper to show in what way the desire to be free can be looked upon as a fundamental psychological urge.

5. Sex differences in reaction to ink blots.

AVANINDRA KUMAR TYAGI, Lahore.

50 boys and 20 girls, (B.A. final to M.A. final) age range 19 to 21 and 18 to 20 years, were used for an ink blot test consisting of eight blots. The responses are analysed more or less after the recommendation of Rorschach. Characteristic differences between the boys, and girls, responses are given and commented on.

6. An experimental inquiry into the problem of values.*

M. V. GOPALSWAMI, Mysore.

Abnormal Psychology

7. Unconscious determinants of sensory experience.

H. P. MAITI, Calcutta.

The purpose of the paper is to report the effect of changes in unconscious attitude of a subject in course of psycho-analytical treatment on the rhythm of fluctuations of his sensory experience in retinal rivalry experiments. The sensory experience in question was limited to red and green stimuli and two series of fluctuation records have been compared, one taken at the interval of 13 days after the other. The subject had 13 psycho-analytic sittings during this interval. An attempt has been made to explain the marked difference in fluctuation records by reference to dreams and other psycho-analytical materials of the subject.

8. A study of puerperal insanity.

I. LATIF, Lahore.

Three case histories are analytically presented with the object of studying the psychogenetic factors in the onset of puerperal insanity. The following factors appear to play an essential role in the psychogenesis of this disorder: (1) certain unconscious incestuous fantasies, (2) unconscious aggressive and hostile fantasies resulting from a deep sense of frustration and deprivation, and (3) a deep-seated sense of guilt which in its turn results in certain phobias, states of acute depression which may alternate with states of manic excitement.

9. Fear of insanity—a variant of castration complex.

I. LATIF, Lahore.

A study of four cases is attempted which shows that in each of these cases the fear of insanity could be traced to an unconscious fear of castration through the mechanism of displacement.

10. The concept of crime.

I. LATIF, Lahore.

An attempt is made to study the concept of crime in its physiological, sociological, penal and psycho-analytical aspects.

* Text of abstract not supplied while reading the paper at the session.

11. Psycho-neuroses in the work situation.

PARS RAM, Bhiwani.

With freedom becoming the cherished value of masses, the traditional modes governing the employer-employee relation bring much individual unhappiness and strain. This paper describes some typical examples of nervous breakdown resulting from the employment situations. The patients mentioned had achieved a remarkably high standard of efficiency in their work so long as the employer for them had been a symbol of potency and forgiveness. The moment he had become the image of revenge the patients lost their self elation and developed symptoms. Persons with unhappy childhood and stormy adolescence cling to their professional work as a defence against neurotic anxiety. Therapeutic measures are suggested.

12. Anxiety symbol in dreams.

N. S. N. SASTRY, Mysore.

The part that symbol play in dreams has been discussed by almost all the famous psycho-analysts and it does not need elaboration here. The paper records the way anxiety manifests itself in dreams.

Two important types of symbols are (1) examination anxiety and (2) catching the railway train. These are shown to be very common. An analysis of these dreams has been effected. The analysis shows that in every case, the experiences tinged with great anxiety repeat themselves as symbols every time anxiety is felt by the individual in regard to any important issue.

13. Study of sleep in a neurasthenic man.

UDAI BHANU, Indore.

An old man, suffering from neurasthenia, weighing 200 mn lbs, having high blood pressure of 200°, lost his sleep at the age of 64 years. He was kept under observation for eight months.

In the absence of any man the subject could sleep for one or two hours. But the presence of any man in the sleeping room disturbed his sleep. This made the observation impossible.

Then he was kept in a relaxed position (*Shava Asan* or Dead pose). At first it was difficult for me to keep him in that condition but after some days practice he could be kept under control. It was seen that he often slept during that pose. This paper is the result of the study of the explicit changes produced during that period.

Summary :—

- (1) During the attack of neurasthenia his sleep was always disturbed. All efforts to induce sleep in him failed.
- (2) In addition to fatigue, the period of excitement also serves as a stimulus. Sleep induced by the stimulation of tactile nerves by massage of oil or passes, was temporary.
- (3) Mental condition and the pose of the physical organism interact on each other.
- (4) The estimating ability and the functioning capacity are two different capabilities.
- (5) It is inferred from the study of this man as well as from others that the sleep centre must be located some where near that Rolandic area which controls the movements of the mouth and tongue.

19. The role of self-aggressive tendency in the formation of mental diseases.

S. M. MOHSIN, Patna.

The two fundamental motives of construction and destruction, love and aggression, are the psychic representatives of the metabolic processes of building up and breaking down. They have each two directions-inward, to the self, and outward, to reality. In the child, love is directed only inward and aggression only outward. The formation of the partial turning of aggression against the self, The Super-Ego observes, punishes and dictates repression,

Many syndromes can be interpreted as due to the inward uni-directional flow of the aggressive tendency. Hence, withdrawal from reality and the retardation of thinking are very common features.

Repression, fixation and regression are to be taken in a modified simpler sense. The Super-Ego dictates repression and so repression is the expression of the aggressive impulses directed inward; the effect of repression is the same on the repressed and the Ego, as is the effect of aggression. Fixation is to be taken in the sense of irreversibility of direction of motives. Regression is the return of the aggressive impulses at the disposal of the Ego to the Super-ego and the intensity of aggressiveness in the latter.

The Super-Ego is accepted by the Ego of the psychoneurotic as the substitute for the lost object and is taken as the Ego-Ideal. Transference is an important stage in analysis. It helps the patient accept the analyst as a substitute for the Super-Ego and relax the resistance to the repressed materials under his persuasion. The Ego regains its lost supremacy, takes over the reins of the aggressive impulses from the Super-Ego and provides them suitable outlets in useful activities in regard to physical nature.

The therapeutic methods practiced by different schools of psychopathologists converge very largely, though the theoretical formulations considerably differ. They all aim at the same practical end—a re-orientation of the motives.

15. A case of stammering.*

S. K. AHMAD, Allahabad.

16. Jung's doctrine of the Anima.*

G. D. BOAZ, Madras.

17. Nutritional background in psychological inadequacy.*

C. K. VASUDEVA RAO, Bangalore.

18. A follow-up study of 55 pre-frontal leucotomy cases.

C. K. VASUDEVA RAO, Bangalore.

Education and Educational Psychology

20. Decadence of education in Bengal—a short review.

NIROD MUKHERJI, Calcutta.

Results of examinations in the various branches of higher education conducted by the Calcutta University this year have shown a serious decline in progress. Attitude expressed by the authorities concerned towards the problems which have led to this decline has been rather superficial. The writer, in this paper, has laid emphasis on the analysis of the basic problems and given indications of the lines of their probable solutions.

Examination of the facts collected go to show that though the number of the students registered for the various examinations have been increasing every year, the number of "good" students has sharply declined in the past decade. The reasons are multifarious. Home environment, mainly due to economical reasons, has extensively deteriorated. The same reason has been responsible for bringing teachers of poor quality in the profession of teaching. Since 1941, rapid inflation in the province, owing to its being placed in the war zone, has precipitated a severe crisis which has had its evil effects on students, their homes, schools and teachers. The famine gave a final blow to destroy the covetable values in education which had survived till recently. The time worn technique of education in secondary schools and colleges in general has met with an insignificant improvement; the only noticeable change, that has been observed in the schools during the last decade, has been the introduction of a somewhat large number of trained teachers—"trained" at the cost of improvement on "teacher quality".

As it may be expected, famine, epidemics and inflation did not leave the institutions unaffected. The worst victims in this direction have been the schools, primary and secondary, and general colleges, which received no aid worth mentioning either from the government or from the University. Attitude of the present government toward our education has not changed since Macaulay's notorious utterance. At the same time,

* Text of abstract not supplied while reading the paper at the session.

the writer feels compelled to state on the basis of facts, that the University failed to extend help to these institutions or teachers and students at the critical hour of our national life.

The political situation prevailing in the province after 1942 left the students without any grasping national leadership to call a halt to their declining morale. It is unfortunate that the University at this juncture instead of serving as the North Star to the aspirants in education allowed itself to be led on communal leadership.

To sum up, it may be said that poor home environment, poverty of students and teachers, backward technique in education have been the major contributory factors to the gradual deterioration in our education. This decay was accelerated by the famine, epidemics and inflation as well as lack of sympathy on the part of the government and the University and absence of healthy national leadership leading into woeful examination results and dissipated morale in the students, the climax of the latter reaching during the last examination periods.

Suggestions have been made regarding immediate changes in policy for improving the standard in education.

21. Intelligence and teaching ability.

T. K. N. MENON and M. M. SHUKLA, Baroda.

Objective measurement of teaching ability is of central importance for the solution of many problems related to the training of teachers. While the factors determining teaching efficiency are studied in a preliminary way in Western countries, methods of assessing teaching ability employed by Indian Universities at present move much in the same traditional grooves. The object of the present investigation is to examine the reliability of the practical examination of B.T. candidates conducted by the University of Bombay by means of a statistical study of the marks obtained by the candidates in their final practical examination.

The subjects of the investigation were three successive batches of B.T. candidates under training in Baroda Training College during the years 1940-41, 1941-42 and 1942-43. All the candidates were given standardized intelligence tests as part of the experimental work in the Psychological Laboratory of the College, and their I.Q.s were calculated. The lists of marks obtained by the candidates were also prepared under two separate heads, (a) Practical classwork (PC), i.e., estimates of teaching ability made by the College staff, and (b) estimates of teaching ability made by external examiners appointed by the University (EE.).

The correlations between (A) IQ and PC, (B) IQ and EE for the three years were calculated. The results showed no significant correlation between candidates' general intelligence and estimates of their teaching ability made by the external examiners, during all the three years. On the other hand, significant relationship was found to exist between the candidates' general intelligence and the verdicts on their teaching ability given by the College staff.

In view of the results of the present investigation and also because of the several factors involved in teaching ability, the methods employed at present by the Bombay University in assessing teaching ability needs modification.

22. Determination of mean-timings for Seguin's Form-board.

NRIPENDRA NATH SEN, Lucknow.

The paper reports the data and conclusions obtained from Seguin's Form-board test on 94 boys aged 8-13, of a local school.

Two trials were given in succession to each subject and the time and errors were noted. The following table summarises the result :—

		7	8	9	10	11	12
i)	Age						
	Time-score in secs. (unpractised) A	47.0	47.6	44.3	44.1	41.6	33.8
	Time-score in secs. (practised) B	43.7	44.0	39.5	38.7	37.3	33.8
(ii)	Mean Error	A	1.14	1.33	0.88	0.90	0.47
		B	0.28	—	—	—	0.21
							0.50

(iii) percentage of errors with each block :—

Block No.	1	2	3	4	5	6	7	8	9	10
A	2.7	17.8	9.5	1.3	4.1	49.3	—	—	13.6	1.3
B	—	—	—	—	8.3	41.5	16.6	—	8.3	16.6

Indian Psychology

23. The psychology of the *Brhadaranyaka Upanishad*.

P. T. RAJU, Guntur.

The *Atman* psychology with its three states—discussions about *prana* Function of the nerves called the *Hitas*—psychic state in transmigration

Vocational Psychology

24. Susupti.*

(Miss) M. FALK, Calcutta.

25. Psychology and the problems of demobilization.

B. KUPPUSAWMY, Mysore.

The Central as well as the Provincial and State Governments are now faced with the tremendous problem of demobilization. Each Government is setting up a Labour Exchange department. It is urged that the Labour Exchange department should make use of the techniques of mental testing in helping demobilized men to find jobs suitable to their talents and temperaments.

* Text of abstract not supplied while reading the paper at the session.

SECTION OF ENGINEERING AND METALLURGY

PRESIDENT : P. H. KUTAR, B.A., B.Sc., M.S., Met.E. (U.S.A.)

1. The geology of Deccan Traps and its bearing on engineering and agricultural problems.

N. S. JOSHI, Bombay.

The paper describes the importance of the geology of Deccan Traps on various agricultural and engineering problems. It explains the formation and the peculiar distribution of soils in the Deccan Trap areas. It describes the important effects that the layers in Deccan Traps and the 3 horizons in each layer, have on a large number of engineering problems, also particularly on the foundations of dams, the losses in transit in Deccan Canals and the very perplexing problems of water-logging and salt efflorescence in irrigated tracts. The most important problem affected by the layers and horizons is that of under-ground supplies of water—so vital to the food problem of India and particularly of Bombay and other Deccan Trap areas.

2. A technical note on high pressure sludge gas compression in Bombay Municipality.

Y. N. KOTWAR, and L. P. BORKAR, Bombay.

The paper describes the theoretical and practical aspects of a compressor installed by the Bombay Municipality to compress and store sewage sludge gas for use as fuel. The theoretical part of the paper considers the volume measurement of high pressure gases, as stored and supplied for high pressure storage vessels. The measurement of pressure-volume relations is governed by three gas laws, i.e.

- (a) Boyle's Law.
- (b) Dalton's Law of Additive Pressures.
- (c) Leduc's Law of Additive Volumes.

Method of calculations based on these laws and the actual volume calculations arrived at are given in tabulated form.

The sludge gas obtained by the anaerobic fermentation of sewage sludge, contains approximately 65/68% methane, 28/32% carbon dioxide, 2/5% nitrogen with traces of oxygen and sulphuretted hydrogen.

On the practical side an attempt has been made to study the findings of the theoretical portion, i.e. the economics of high pressure compressor working and how far the washing out of carbon dioxide from the sludge gas is really advantageous from actual transport point of view. An examination of this problem has led to the conclusion that the washing out of carbon dioxide from the sludge gas is not justifiable and the compression of unwashed gas as such in the storage and lorry cylinders would result in a very great advantage both from an economical and practical point of view.

3. Jamshedpur water-supply restoration after damage by floods in 1943.

V. N. SARANGDHAR, Jamshedpur.

The paper deals with the practical methods undertaken to restore the water supply of Jamshedpur after it was very badly damaged by floods in the river Subarnarekha in 1943.

4. Protective earthing of electrical equipment in factory installation.

P. K. BHATTACHARYA and K. S. KUKA, Jamshedpur.

Earthing of electrical equipment is perhaps as old as the electricity itself. However, the fundamentals of earthing and the behaviour of earth electrodes are being care-

fully studied only during the last few years. There is still a great difference of opinion prevailing amongst engineers, regarding the method and effectiveness of earthing as a safety measure. Earthing in many cases is carried out in a laissez faire manner, often depending on the whims of the person in charge of the installation. Though money and labour are spent to a great extent, most systems will be found to be fundamentally defective and often dangerous.

This paper discusses various earthing practices followed in factories, showing the limitations in each case. A procedure is developed, which should lead to the most suitable method, depending on the conditions prevailing in the factory.

Effects of electric currents on human beings are also discussed, in the light of recent experiments carried out. Equations for the magnitude of electric shock voltage are derived and practical methods of measuring the shock voltage and the earthing resistance are described, giving the fundamental relationship between them.

5. Short circuit current calculations on low voltage systems.

K. S. KUKA and D. J. BHADURJI, Jamshedpur.

The study of short circuits in high voltage systems has been the subject matter of many articles in technical journals. However, scant attention has been paid to similar problems in low voltage distribution systems. An attempt is made in this paper to present the problem of short circuit currents in low tension distribution systems in its fundamental aspects. Equations for reactances of various equipments, viz., circuit breakers, current transformers, busbars etc., are given, which are not easily available. For power transformers, cables and overhead lines, graphs are given for ready calculations of the reactance and resistance values for standard sizes. A graphical method is derived in this paper to calculate the final short circuit current at any point on the low tension distribution system. The method developed will be handy and helpful to distribution engineers, to enable them to give adequate consideration to the planning of their systems. Specific cases of short circuit faults in a distribution system are considered and the short circuit current values under varying fault locations are compared to show the effects of each equipment connected.

6. Automatic load control in times of breakdown in generating stations during heavy load periods.

J. D. ENGINEER, Jamshedpur.

The purpose of this paper is to show how the selected outgoing feeders in a generating station or in a substation at the remote end can be tripped off promptly and automatically in order to maintain station stability in case of any turbine or generator failure during heavy load periods and also to guarantee the maximum power supply up to 125% of the total generator capacity on load.

It is suggested that a Generator Trip Relay should be installed near every Turbine Trip Lever in order to trip off its generator promptly if the turbine trips off automatically or is tripped off manually due to any mechanical trouble.

A Thinking Relay is also designed here with its Special Current Transformer and Selective Feeder Tripping Board in order to trip off the selected outgoing feeders when the total load on the generating station exceeds 125% of the total capacity of the generators on load at that station, due to any one generator going off the line automatically. This relay is inoperative if any generator is tripped off manually or even if all generators get overloaded. This is essential as Over Load relays are provided for the job.

Finally, it is also suggested that important station auxiliary layout should be such that in case of power, motor or pump failure the stand-by unit will go promptly and automatically into service.

7. Developments in the electro-smelting of iron ores.

N. S. SHANKARIAH, Bhadravati.

The paper is a review of the existing literature on the subject. The development of the electric furnace for smelting iron ores is traced from its earliest experimental forms to the modern successful types. The three successful commercial types—Electro-metal, Tysland Hole and Siemens and Halske furnaces—with their operating features are discussed. The Wiberg-Söderfors process for making sponge iron utilising electrical energy is also described and its operating results given. Finally the advantages of electric smelting and economic aspects to be considered are mentioned.

8. Pig iron for castings.

B. RAMASESHIAH, Bhadravati.

The classification and grading of pig iron used in foundries, the analysis of the different grades of Indian pig iron and the selection of suitable grades for various types of foundry work, are discussed in the paper. Details of the experiments carried out at the Mysore Iron & Steel Works on the use of charcoal pig iron for the manufacture of chilled iron castings and other specialised castings are presented.

The specifications for pig iron laid out by foreign countries require to be modified in respect of indigenous products, particularly on the size, shape and weight of the pigs.

The effect of the use of steel scrap in the cupola, the use of a mixture of coke and charcoal pig irons and the effect of change of fuel during smelting in the blast furnace have been discussed. The influence of various alloying elements in pig iron, particularly of silicon and manganese, with reference to the experiments carried out on the Mysore Iron & Steel Works have also been described.

9. Steel making.

R. A. M. WRIGHT, Jamshedpur.

The notes illustrate the development of suitable bricks commencing with a brief general résumé. The paper shows the variable conditions encountered in the making of steel by the acid and basic processes, and the development of slag control for refining. It shows that slag varies in composition throughout the process.

The conclusions point out empirical yet practical indications of changing conditions due to temperature.

10. Manufacture of alloy steels.

H. S. SASTRY and M. V. PATANKAR, Bhadravati.

Due to the conditions brought about by the war, the Mysore Iron & Steel Works found it difficult to import alloy and tool steels. In order to meet their own works demand various grades of alloy and tool steels were manufactured in a crucible Hoskins furnace. Larger demands of alloy steels were met from a 3-ton arc furnace. Experimental details on the manufacture of high speed steels of the tungsten, cobalt-tungsten, and tungsten-molybdenum types and the heat treatment of these steels are described. The range of steels, manufactured at the Mysore Iron & Steel Works on a small scale, includes wear and heat resisting steels, stainless steels and acid resisting alloy castings.

11. Hardenability of steels.

DARA P. ANTIA, Calcutta.

To stimulate research on alloy steels made in India, a brief review of the work done in America on hardenability of steels is presented. Hardenability is defined and hardenability tests examined. Relation of hardenability to quenching and the physics of hardenability along with the factors affecting hardenability are discussed. Relation of hardenability to melting practice is stressed and the need for alloy steels is clarified.

12. Austenetic manganese steel

H. S. SASTRY and M. V. PATANKAR, Bhadravati.

The well-known Hadfield manganese steel is manufactured at the Mysore Iron & Steel Works, Bhadravati in the basic lined electric arc furnace by the double slag process. The heat treatment of the high manganese steel castings is carried out by quenching the castings from a temperature of 1875 to 1925 deg. F. in cold water. The paper discusses, the production methods, the mechanical properties of high manganese steel and the influence of alloying elements on its physical characteristics.

13. The rolling of steel sections at the Mysore Iron and Steel Works.

K. NANJAPPA, Bhadravati.

A modern steel plant comprising two open hearth furnaces and a 3-ton electric arc furnace was put up in Bhadravati in 1936. A steel rolling mill for rolling large number of ordinary commercial sections, a 20" roughing mill and 12" and 10" finishing mills together with a strip mill with suitable ancillary equipment have been installed. The paper describes the rolling mill equipment and the rolling process for obtaining various finished sections. The finished products undergo careful inspection before despatch. A general outline of the flow of material from the furnace to the finishing end has been given.

The welfare measures taken by the Company in the interest of the employees have also been mentioned.

14. Some observations on 'cut necks'.

G. P. CONTRACTOR and S. VISWANATHAN, Jamshedpur.

The term 'cut necks' is used to describe a certain type of wear of roll necks while rolling sheets in the two high pull-over mill. In this paper an attempt is made to analyse the contributory causes that result in 'cut necks', from the standpoint of the more general phenomenon of wear. The possible methods of minimising the sources of trouble are also indicated.

15. Non-destructive testing of materials by magnetic, radiographic and general methods.

D. D. JANGALWALA, Jamshedpur.

The various methods of testing materials which fall in the category of non-destructive testing are broadly classified and as there are numerous methods of non-destructive testing, only a general description of the principles and their applicability to industrial testing are given. Magnetic and radiographic methods have, in recent years, made many great strides in the field of engineering industries and these methods are discussed in detail. Other general methods of non-destructive testing are also dealt with and in the concluding part of the paper, the merits of the various methods of non-destructive testing are briefly compared and the advantages of a few methods are discussed in the light of their suitability to particular problems of testing. The future of the non-destructive methods of testing is discussed with special reference to the growing interests stimulated by the present improved technique.

16. Determination of alumina in chrome ore and chrome-magnesite refractories.

H. P. SAMANTA and N. B. SEN, Jamshedpur.

Errors involved in the method of determination of Al_2O_3 in chrome ore and chrome-magnesite refractories from the water leach of a Na_2O_2 fusion (Industrial Minerals and Rocks, p.202, 1937, Standard Methods of Analysis, by Scott, Vol. I, p.297, Methods of Analysis of Ores etc., by Phillips, p.158, Analysis of Steel Works Materials, by Ibbotson) after boiling the same with NH_4Cl are indicated.

In describing this rapid and routine method, the residue left after the peroxide fusion has been overlooked by the authors in the above reference. But on analysing separately, varying percentage of the oxide is found in the residue. It has also been found that the higher the percentages of SiO_2 and MgO in the chrome material, the greater is the error. In chrome-magnesite bricks of various types, the analyses of the filtrate from the Na_2O_2 fusion do not show more than 2 to 4%, when actually the total content of Al_2O_3 in the bricks is from 7 to 10 percent. Chrome ores having 8 to 12% Al_2O_3 invariably show 2 to 4% lower results by this method.

17. Determination of ferrous oxide in chrome ore and chrome-magnesite refractories.

H. P. SAMANTA and N. B. SEN, Jamshedpur.

A careful study is made to establish a rapid and accurate method for the determination of ferrous oxide in chrome ore and chrome-magnesite brick. The iron oxide

content of some Bihar chrome ores show interesting results, Fe_2O_3 predominating in major cases. Shein's method (Zavodskaya Lab., 6, 1199—1205, 1937, C.A. 779499, 1937) modified by the authors is found to be the best and reproducible. The method is also checked by determining FeO from the increase in weight obtained by heating in an atmosphere of pure N_2 first and then in O_2 . Two methods give almost identical results.

The solution of the ore is effected with 2 : 1 phosphoric acid and concentrated sulphuric acid at about 360°C in presence of a known weight of chemically pure V_2O_5 . The excess of unreduced V_2O_5 is then determined by titration with standard ferrous sulphate using diphenyl-amine as internal indicator. The difference of ferrous sulphate between this titration and that obtained by dissolving the same weight of V_2O_5 in a similar way gives the amount of ferrous iron in the sample.

The effect of heating chrome ore to various temperatures is also studied. It is observed that oxidation of FeO into Fe_2O_3 begins even at as low a temperature as 850°C and is complete within four to five hours at this temperature.

These experiments show that iron cannot remain in the ferrous state in fired chrome-magnesite bricks. This is also confirmed by negative results obtained in the determination of FeO in these bricks by the above method.

18. An investigation of the pyridine-method for the separation of some elements in the analysis of alloy steels.

H. P. SAMANTA, Jamshedpur.

A critical study has been made of the pyridine-method of separation in determining some of the elements in high-speed steels, permanent magnet and other alloy steels and alloys of alnico type. The method is found to be more elegant and less time-consuming than the most widely used routine and umpire method of zinc oxide separation and also gives accurate and reproducible results.

Double precipitation is not necessary, as the tendency of absorption by precipitates is reduced to minimum by the fact that nickel, cobalt, copper and manganese form soluble complexes with pyridine and the precipitation is carried out in an acid medium. No difficulty is encountered for subsequent estimations of all these elements from the filtrate.

It has been noted also that molybdenum and vanadium quantitatively separate with hydrous oxides and there is no distribution of cobalt in presence of molybdenum and copper, as is the case with the zinc oxide method.

Results of typical analysis of British chemical standard steels and commercial varieties of alloy steels of divergent compositions are presented and compared.

19. The analysis of synthetic steels (Cr samples) by the spectrograph—a method in correlation.

B. N. BHADURI, Jamshedpur.

Synthetic steels of the chromium variety were prepared in the high-frequency induction furnace of the Laboratory and analysed. The spark technique method of exciting spectra was used. Method of correlating results from plate to plate was devised and applied to the analysis. The method of correlation which has been explained, consists of two parts, the first being the extrapolation beyond the range of working and the second, the method of finding determinant curves within the range. Some examples from the analytical work with the samples are given. Actual applications of the method are being used at the laboratory for the estimation of certain elements in alloy steels.

20. Investigations on colorimetric methods of metallurgical analysis. Part 11—A simple method for the colorimetric estimation of molybdenum in alloy steels

G. V. L. N. MURTY, Jamshedpur.

A simple visual colorimetric procedure (standard series method) based on Vaughan's photo-electric estimation of molybdenum in alloy steels has been described. It is shown that the colours developed by dissolving the samples in Spekker acid and treating

with potassium thiocyanate and stannous chloride are sufficiently stable to yield reliable results by visual comparisons. The residual red colour due to iron has been shown to be incapable of causing any serious interference. The results recorded indicate that the suggested procedure which is rapid and convenient for routine work compares very favourably in regard to the accuracy attainable with the gravimetric and photo-electric methods.

21. Investigations on colorimetric methods of metallurgical analysis. Part III—Permanent standards for the colorimetric estimation of molybdenum in alloy steels.

G. V. L. N. MURTY, Jamshedpur.

The paper deals with attempts to overcome the disadvantage of inappreciable stability of the colour involved in the visual colorimetric estimation of molybdenum in alloy steels (Part II of this series). Effecting modifications in the procedure or adding perchloric acid have resulted in increasing the stability only up to eight hours. Attempts made to explore the possibilities of preparing duplicates of these colours by suitably mixing solutions of judiciously selected inorganic substances have been described. It is shown that satisfactory duplicates which cover the entire range in view and remain stable for more than a month may be prepared by employing mixtures of potassium dichromate and cobalt nitrate solutions.

22. Investigations on colorimetric methods of metallurgical analysis. Part IV—Colorimetric estimation of nickel and molybdenum in alloy steels employing the Duboseq type of colorimeters.

G. V. L. N. MURTY, Jamshedpur.

It is shown that improved accuracy accompanied by a remarkable ease in colour matching may be attained by using appropriate light filters in conjunction with the usual Duboseq type of colorimeters. Results have been recorded for the estimation of nickel and molybdenum which show that satisfactory analysis can be made in these cases even with ordinary colorimeters by adopting the absorptimetric procedures and employing suitable light filters. These procedures which are applicable only to low chrome steels (Cr > 8%) compare very favourably in regard to the accuracy attainable with the gravimetric and photo-electric methods of analysis.

23. Investigations on colorimetric methods of metallurgical analysis. Part V—Photo-electric estimation of silicon in steel.

G. V. L. N. MURTY, Jamshedpur.

It is shown in this paper that the discrepancies in the values of drum differences encountered in the photo-electric estimation of silicon could be obviated by using fresh (not more than two days old) stannous chloride reagent and observing the following modification in the procedure :

"After the addition of ammonium molybdate solution the mixture is kept warm at a temperature of about 40°C for five minutes, cooled to the room temperature and dealt with as usual."

As for the time intervals it is noted that it is enough to wait for five minutes after the addition of stannous chloride instead of fifteen minutes. It is also suggested that sulphuric acid may be added after an interval of at least two minutes.

24. Nitrogen and sulphur of coke and its composition.

A. T. BHATTACHERJEE and M. P. GUPTA, Jamshedpur.

This investigation has been undertaken with the idea of finding out the nature of existence of nitrogen and sulphur as well as of oxygen and hydrogen in coke, as the works done so far do not throw much light on this problem. The experiments carried out so far have yielded the information given below :—

(1) Major portion of S (80-90%) is present both in coal and coke in the form of organic S,

(2) HCl acid treatment of coal and coke shows that in the former there is a loss of N_2 , at least a part of which is eliminated in the form of NH_3 and it also loses its caking properties, while in the latter there is no such loss showing that the orientation of N_2 is different in the two cases.

(3) N_2 and S ratio shows that N_2 present in these coals is roughly 5-10 times more than S in atomic proportion and when these are converted into cokes, more N_2 is eliminated in atomic proportion than S, indicating that the configuration of N_2 and S is either different in the original molecule or they behave differently towards heat.

(4) It is not possible to de-ash coals completely by ordinary process of treatment.

(5) Inorganic materials are in no way responsible for the retention of S and N_2 in coke.

25. The future coal policy of India

S. N. SIRCAR, Jamshedpur.

India's reserves of coal are estimated to be 125,000 million tons i.e. about 1.8% of the world's reserve. Of this, about 1300 million tons are stated to be superior coking coal suitable for metallurgical industry. The production and consumption of coal in India is very small as compared with the more industrially advanced countries of the world. Coal will continue to be the principal fuel and being vitally important for the expansion of Indian industries, the scientific working and utilisation of coal is essential. Up till now the efficient mining and utilisation of coal have been neglected and therefore it is suggested that the limited reserves of the country should be carefully examined and worked scientifically in accordance with a national policy.

The assessment of all kinds of coal to permit proper planning of production according to the requirements of the country, proper grading and standardization of coal with the modifications to be made in the existing "grading" to show coking and swelling properties and a scientific co-relation of coal preservation and coal utilisation are the steps proposed.

The question of coal conservation should be approached from the following angles :—

- (a) Unification of royalties and amalgamation of small mining properties
- (b) Rational production of coal.
- (c) Rational utilisation.
- (d) Direct method of conservation by compulsory stowing.
- (e) Super-power station in the coal fields.
- (f) Electrification of railways around Calcutta.

The application of scientific methods to the control of fuel consumption, the welfare of coal miners and the institution of research have been discussed.

26. Petrographic data on some Indian refractory materials

H. K. MITRA and J. C. BANERJEE, Jamshedpur.

Study of Indian refractory material under the petrographic microscope, does not appear to have received sufficient attention. Petrographic data on India Silica and magnesite brick have been presented as also those on some foreign bricks for comparison. Co-related data like true density, thermal expansion, etc. have been included for a better appreciation of the petrographic data given.

27. Data on Indian refractory materials

H. K. MITRA and T. W. TALWALKAR, Jamshedpur.

Published data on Indian refractory material are meagre, and are principally confined to chemical analysis. Physical data have not been readily available so far, as, prior to the establishment of the Refractories Research and Testing Laboratory at Jamshedpur by the Tata Iron & Steel Co. about ten years ago no fully equipped laboratory for refractories study existed in India. Some of the data collected in this laboratory on Indian refractory materials are presented. Data on corresponding foreign materials are also included.

28. Regional planning for Mysore zone.

B. S. N. RAO, Bangalore.

My investigations on the development of regional planning schemes for the zone of Mysore, indicate that three defined schemes could be developed on the model of

the multipurpose T. V. A. Scheme of United States of America. The Sharavati Basin could be diverted towards the harbour point at Bhatkal. The waters of the river Tunga and Bhadra could be diverted into the river basins of Yagachi, Hemavati, Shimsha and Vedavati basins in the central part of Mysore. The waters of Kabini could easily be diverted either to Bhavani or the Cauvery at the farther end.

While preparing the blue print sheets for schemes of this nature the following scientific investigations are quite necessary :

1. Hydrological study of river basins
2. Aerial survey maps of the Zone in question
3. Geophysical data of the Dam sites

As regional planning schemes for other regions in India, for example, the Damodar Valley and the Mahanadi, are under investigation by the Government of India, it is high time that the scientists and engineers took up the study, investigation and collection of the above data at an early date. The available data at present on these aspects are quite inadequate and the number of scientific personnel for tackling such schemes is found to be too small for the many projects which have to be launched out very soon in India.

29. Secondary non-ferrous metals.

A. SCHWARZ, Bombay.

The secondary non-ferrous metal industry has grown steadily, during the last two decades, in the great industrial nations of the world. The failure of primary metals to satisfy the enormous demands of war production, particularly in the matter of tin and copper, served to hasten the progress of this vital field of metallurgical activity. In the United Kingdom, during the years 1942-1944, no less than 38.4% of the total non-ferrous metal consumption was accounted for by secondary non-ferrous metals. Still more spectacular results were achieved in America, where, in 1944 alone over a million short tons of non-ferrous scrap was treated.

In India, the best we have done so far is to extract secondary non-ferrous alloys from scrap. For the rest, our requirements of primary metal are still imported at inflated prices, while we continue to export valuable scrap at deflated prices. Consequently, there is almost unlimited scope for expansion in the field of secondary metal refining, especially as far as the recovery of pure copper and tin is concerned.

The paper discusses, with reference to the relevant Patent Applications, some of the most recent processes developed, both in Europe and America, for the recovery of secondary copper, tin, lead, zinc, aluminium and magnesium.

It is an incontrovertible fact that the secondary metal industry plays a leading role in the economics of the metal trade in general. India, on the eve of industrial expansion, can no longer afford to ignore this issue. A full-fledged secondary metal industry in India would create large-scale employment; ensure the country's independence from imports of primary metal, in case of emergencies, for a number of years; and prove a most attractive commercial proposition.

Planners entrusted with the task of shaping India's industrial expansion should therefore, give adequate consideration to these vital factors.